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A MONOGRAPH

OF THE

MOLLUSCA FROM THE EOCENE FORMATIONS OF ENGLAND.

FIRST CLASS—*CEPHALOPODA.* CUVIER.

MOLLUSCA BRACHIATA. *Poli.*
CÉPHALOPODES. *Lamarck; Férussac.*
CÉPHALOPHORES. *De Blainville.*

THE Cephalopoda form the first class of Molluscous Animals in the system proposed by Cuvier, and consist of the several encephalous mollusca whose organs of reptation are attached to the head. Possessing an organization more complicated and more fully developed than that of the other molluscs, they have a higher rank in the scale of existence. In a descending series they immediately succeed the Vertebrata.

It is in this class that the latest indication of an internal skeleton will be found. Among the more highly organized of the Cephalopods, the cephalic ganglia, to which, from their importance and development, the term *brain* may still be applied, are surrounded and protected by a cartilaginous process, called *the cranial cartilage*, analogous with the cranium of a vertebrate animal, and in which the muscles of the arms and tentacula are inserted. Other cartilages, subservient to the muscles of the funnel and of the fins, where those organs exist, will be found in other parts of the body, and may be said to represent, in rudiment, those portions of the skeleton which in the vertebrate animals sustain their locomotive organs.

The Cephalopods are eminently social animals; they are all predatory and voracious in the extreme, and appear to be nocturnal or crepuscular in their habits. Some, the more highly organized, inhabit the deep seas only; others frequent the coasts or shallow seas, or conceal themselves in holes in the rocks. M. d'Orbigny, to whose recent work entitled 'Mollusques vivants et fossiles' I am largely indebted, shows that to these various habits the zoological peculiarities of the different genera are referable; and he distinguishes the animals as pelagic (pelagiens), or littoral (côtiers), according to the fact of their frequenting the deep sea or the coasts.

The Cephalopoda have a distinct head, surrounded by arms or tentacula; they possess organs of sight and hearing, closely resembling those of vertebrate animals,

and they are endowed with the sense of smell. The eyes are placed on the sides of the head, and in one of the two orders into which the animals are divided (the Dibranchiata) are, generally, lodged in an orbital cavity in which they move freely; in some genera, however, they are united to the outer integument, and are then incapable of motion. When lodged in orbital cavities, they exhibit two distinct modifications, of which M. d'Orbigny has availed himself for the subdivision of the order into two groups (called respectively *Myopsidæ** and *Oigopsidæ*†). In the first modification, which is found among the littoral Cephalopods, the eyes are wholly covered by the skin of the head, which becomes thin where it passes over the ball of the eye; in the other modification, which characterises the pelagic species, the orbital cavity is largely open, and the eyes are in contact with the water.

In the tetrabranchiate Cephalopod, whose food is found principally at the bottom of the sea, and to whom enlarged vision would be comparatively useless, the eye is not lodged in an orbital cavity, but pedicillated, and assumes a simpler structure, approaching that of the inferior mollusc.

These animals possess an external auditory opening, generally protected by an external ear more or less complicated in structure. The organs of smell are supposed to reside in certain pores or sacs, opening externally, termed by M. d'Orbigny *aquiferous pores* (ouvertures aquifères), which are divided into *cephalic*, *oral*, *anal*, and *brachial* pores according to their position, and are used by him as generic distinctions. The mouth is terminal, and is furnished with two strong, horny beaks or jaws termed *mandibles*, working vertically upon each other like the bill of a parrot, with which they are usually compared.

The body is inclosed in a thick membranous skin or mantle, united along the belly of the animal so as to form a muscular bag or sac, open at the upper extremity, and containing the branchial apparatus and viscera. In its general shape it is round, or more or less elongated, and cylindrical or depressed. To this body, distinguished as the posterior portion of the animal, the anterior or cephalic portion, consisting of the head and the arms or tentacula it sustains, is attached by one or more ligaments, some internal, others formed by the continuation of the skin of the body, and termed *cervical* or *lateral ligaments*, according to their position. The condition of these ligaments varies with the habits of the animal, and upon it generic characters are founded. They attain their greatest strength in the littoral Cephalopods, and in some genera afford a sufficient attachment between the head and the body; but in the Cephalopods more or less pelagic, in which the free and independent use of the organs of prehension, and a simultaneous active exercise of the bodily locomotive function, would be materially impeded by an extensive permanent attachment, the ligaments are considerably reduced; so much so, in fact, that they would afford a very imperfect

* Myopsidæ; from μυω claudo, οψις visus.

† Oigopsidæ; from ὄιγω aperio, οψις visus.

guard against the resistance caused by the rapid motion through the water of a mass so large as the cephalic portion of the animal. To obviate this defect, a peculiar apparatus is found in various Cephalopods, which, capable of being instantly brought into action, provides an additional and firm attachment of the head to the body. This apparatus is variable in form, and, except in three genera in which it is not found, forms one of the most certain generic characters. It consists of one or more cartilaginous or fleshy protuberances, placed on each side either of the inner surface of the body or of the base of the head, which fit into corresponding holes or depressions formed for their reception in the opposite part of the head or body. This apparatus, termed by M. d'Orbigny the apparatus of resistance (l'appareil de resistance), has relation to the swimming power of the animal, and is more or less complicated as that increases or diminishes.

The respiratory apparatus consists of two or four lamelliferous branchiæ or gills, lodged in chambers contained in the visceral sac, but separated from the viscera by a membranous partition. The number of these gills has been adopted by Professor Owen as an ordinal distinction; and, in the system of classification proposed by him, to which I shall hereafter refer, the Cephalopods are divided into *dibranchiate* and *tetrabranchiate* orders according to the fact of their possessing two or four branchiæ. Into the chambers containing the gills, the water is freely admitted by a valvular aperture, and having served the purpose of respiration, flows, or is forcibly ejected by the muscular contraction of the body, through the excretory tube or funnel (*infundibulum*). The water thus expelled in streams more or less powerful and frequently repeated, at the will of the animal, causes a retrogressive movement, which forms its principal mode of locomotion, from which circumstance the tube itself is called by M. d'Orbigny the *locomotive tube*. The body thus becomes the most important locomotive agent; and as its size and shape must materially influence the retrogressive motion, we can readily conceive that they will have relation to the exigencies of the animal for swimming. Thus the pelagic species, in which the body, from its comparative size, and its cylindrical form and tapering extremity, is adapted to contain a large quantity of water, and to move through the sea with facility, are, as their necessities would require, pre-eminently powerful swimmers; while, on the other hand, in the littoral species, to which great retrogressive power would be not only unnecessary, but a source of frequent injury, the body is small and rounded, or depressed, so as to afford a broad surface on which the animal can rest upon the ground.

Among the dibranchiate Cephalopods the circulation is performed by the agency of a central or systemic heart, of two lateral hearts, subservient to the propulsion of the blood through the branchiæ, and thence called the *branchial* hearts, and of a venous system consisting of two principal vessels, *venæ cavæ*, contained in a cavity called by Professor Owen the *pericardium*, and communicating freely with the branchial chambers, and of other subordinate trunks or vessels. In this cavity terminates the

tube called the *siphon* or *siphuncle*, which perforates and traverses the chambers of all the multilocular shells, whether external or internal,* and by means of which, as it has generally been supposed, the animal can diminish or increase the specific gravity of the shell, and so facilitate its rising or sinking in the water.

In the recent *Nautili*, the sole living representatives of the tetrabranchiate Cephalopods, the lateral hearts are wanting, the enlarged surface of the branchial apparatus rendering such additional means of circulation unnecessary.

The funnel or locomotive tube is placed beneath the head, and supports at its base the apparatus for resistance before noticed. Its functions are various; it conveys away the water inhaled for respiration after that object has been served, and, as we have already seen, becomes, at the will of the animal, the principal locomotive agent; it is also the excretory tube. The condition of this organ is used by Professor Owen as an ordinal character; in the dibranchiate Cephalopods the parietes of the funnel are entire, while in the tetrabranchiate Cephalopods they are disconnected along the ventral margins.

A peculiar provision for defence is found among the naked Cephalopods, which is denied to those protected by an external shell; this provision consists of an organ for secreting and expelling an inky fluid, by the effusion of which the animal, when alarmed, is enabled to discolour the surrounding water, and thus to facilitate or conceal its escape. The fluid is contained in a bladder-shaped sac, called the *ink-bladder*, and its presence may be regarded as a certain indication of the dibranchiate type of organization.†

In addition to the retrogressive power possessed by all the Cephalopods, and derived from the agency of the funnel, the decapodous genera are provided with lateral or terminal fins, more or less coriaceous, according as the habits of the animal are more or less pelagic or littoral. The motive function of the fins, however, appears to be secondary; those organs being used chiefly to sustain or steady the animal, and direct its course through the water. The position of the fins is used as a generic character.

The dibranchiate Cephalopods carry on their heads eight or ten arms, the place of

* In M. de Blainville's "Mémoire sur l'Animal de la Spirula et sur l'Usage du Siphon des Coquilles Polythalames," the siphuncle is described as a solid tendinous prolongation of the retractor muscles, by means of which the animal is enabled to withdraw the cephalic mass within a cavity formed by the anterior extremity of the mantle, and thus to regulate the specific gravity of the body. It appears, however, from Professor Owen's examination of two specimens of *S. Peronii* (*fragilis*), captured and brought home by Captain Sir Edward Belcher (see Zoology of the Voyage of the Samarang), that the soft or membranous siphon is in reality a *tube* continued from the calcareous siphon and the last chamber of the shell, through a semicircular aperture in the mantle, into the visceral cavity.

† M. d'Orbigny, after referring to these means of escape in the Sepiæ, says (Moll. Viv. et Foss., vol. i, p. 134), that he is far from believing that the faculty is enjoyed by every species; and that, in fact, if it exists among the Sepidæ, it is at the least doubtful among the other Cephalopods, who possess but a small quantity of the liquid, which they only expel when dying.

which, in the tetrabranchiate Cephalopod, is supplied by a multitude of tentacula grouped around the mouth. These arms or tentacula are organs as well of locomotion as of touch and prehension. In the dibranchiate Cephalopod the arms are furnished with suckers (*acetabula*), and are of two kinds, viz.: eight *sessile* arms encircling the mouth, and connected at the bases by a muscular web more or less broad; and two *tentacular* arms placed one on each side, and capable of considerable extension. The Octopods are furnished with the sessile arms only; the Decapods possess also the tentacular arms. The development of the sessile arms appears to be in inverse ratio with the retro-swimming power of the animal, and, consequently, as we have before seen, with the size of the body. In the pelagic Decapods, which possess the highest retro-swimming power, and whose body is comparatively large, the arms are short; while in the finless Octopods and the littoral Decapods, which have small bodies, and are consequently bad swimmers, and whose habits require the means of creeping along the ground, the arms are infinitely larger, and the connecting web is broader, so that they serve also for reptation.

The arms, to adapt them more perfectly for prehensile purposes, are provided with suckers placed *in serie*, on the inner surface. These are sometimes simple, i. e. *unarmed;* but in some genera they are surrounded by a horny dentated hoop, and in others are *uncinated*, or armed with sharp, horny hooks. When the prey is once seized by this formidable apparatus, escape is hopeless. In the tetrabranchiate Cephalopod, which is always attached to a dense calcareous shell, and whose principal food appears to be the crustacea or testacea living at the bottom of the sea, the complicated mechanism of the arms entirely disappears, and the animal is provided with numerous, small, retractile tentacles, by which the sense of touch, as necessary to it as enlarged vision is to the dibranchiate Cephalopod, is largely developed.

The presence of the sucker bearing arms, or of the tentacula, is an ordinal distinction, and has been adopted by the French naturalists for the designation of the two orders, corresponding with the dibranchiate and tetrabranchiate orders of Professor Owen, into which they have divided the Cephalopods; the armed and unarmed conditions of the suckers are also used as subordinal and generic distinctions, and characters of families and genera are founded upon the retractile power of the tentacular arms.

Exclusive of the impulsion derived from the funnel, and the capacity to rise and float in the sea which the chambered and siphoniferous shell affords, the tetrabranchiate Cephalopod can only creep, like the gasteropods, along the bottom of the sea by means of the free and expanded margin of the anterior extremity of the body.

The animal whose zoological peculiarities have been thus cursorily noticed, is sometimes lodged in a symmetrical shell, *unilocular* or *camerated* (multilocular), that is, presenting a series of chambers divided from each other by thin partitions (*septa*), and successively added by the animal to meet the exigencies of its increasing bulk, and in

the last of which the body is contained. The partitions present the greatest variety of form; being in fact moulded upon the animal, they indicate corresponding zoological peculiarities, and generic distinctions have been founded upon them. Among the *Nautilidæ*, one of the families into which the tetrabranchiate Cephalopods are divided, the posterior extremity of the body is round and without any projecting part, or *lobe* as it is termed, and the septa therefore are characterised by simple curvatures or undulations, and their margins are always entire; and thus we are led by analogy to believe, that in the *Clymenidæ* the animal had an angular lobe on each side of the body, from which the sinus, which characterizes their septa, would take its form; and that in the *Ammonitidæ* the posterior extremity of the body had many lobes, the edges of which were foliated, whence the septa assumed corresponding curvatures with foliated margins. Sometimes, and this is most generally the case among the recent Cephalopods, the animal is without the protection of an external shell; but it is then supplied either with a calcareous chambered shell almost wholly buried in the animal, or with a horny or calcareous substance, simple, or more or less complicated in form and structure, wholly internal, and encysted in the back of the mantle. From the presence or absence of the external shell, the Cephalopods have been, and in fact still are, popularly divided into shell-bearing and naked Cephalopods, although in the systematic arrangement proposed by Professor Owen these terms have a more restricted application.

The chambered shells are characterised by a peculiar apparatus, by means of which, as it has been generally supposed, they are made subservient to hydrostatic purposes, although the precise mode by which that end is attained is merely conjectural. From Professor Owen's description of the *Nautilus Pompilius*, it appears that the posterior part of the visceral sac is prolonged in the form of a membranous tube, which, passing through a short calcareous collar, formed in the disc of each septum, and called the *testaceous siphon*, traverses the different chambers to the extreme nucleus of the shell. This tube, with the calcareous collar which, more or less, covers and protects it, is termed the *siphon* or *siphuncle*, and is found in all the multilocular shells strictly so called, whether external or internal, recent or fossil; and its position with reference to the margin of the shell, is used as another distinction between the *Ammonitidæ*, the *Clymenidæ*, and the *Nautilidæ;* being ventral or external, that is, placed near the outer margin, in the Ammonitidæ; central, that is, at or near the middle of the disc of the septum, in the *Nautilidæ;* and dorsal, that is, close to the preceding volution, in the *Clymenidæ*.

The process by which the external shells of the Cephalopods are constructed does not appear to differ essentially from that used by the inferior molluscs. Professor Owen has described the mode of growth in the *Nautilus Pompilius;* and we are led by analogy to the conclusion, that the shells of the extinct *Nautili* and the *Ammonites*, and their various cognate genera, were formed in the same way. In the recent

Nautilus the animal is attached to the shell by two large lateral muscles, called the *adherent* muscles, and by a belt or *cincture* of horny matter, which completely encircles the posterior part of the visceral sac, and expands at the sides into broad discs, which serve as the medium of insertion of the adherent muscles; and the prolonged posterior extremity of the visceral sac, forming the membranous siphuncle, is a third mode of attachment. As the animal increases in size, the adherent muscles and the cincture gradually advance their line of attachment, and the membranous tube at the same time lengthening in proportion, a cavity is thus formed between the septum and the lower portion of the visceral sac. A deposition of calcareous matter by the surface of the mantle then takes place, commencing at the sides of the shell, and proceeding towards the membranous tube, round which it is continued backward, and forms the *calcareous* or *testaceous* siphon. Thus, as the animal increases in bulk, the dwelling-chambers are successively formed and converted into air-chambers, by means of which the specific gravity of the shell and its contents is maintained nearly in equilibrio with that of the surrounding water. During the growth of the animal the anterior portion of the mantle secretes calcareous matter, which it deposits in successive layers on the margin of the aperture; and thus the enlargement of the outer wall of the shell is effected. I must add, that the theory of the gradual advance of the adherent muscles and the cincture during the growth of the animal is opposed to the opinion of M. d'Orbigny, who, in his hypothesis as to the function of the siphuncle, noticed subsequently, maintains in effect, that the advance of the muscles (and, I presume, of the cincture also) is periodic.

The Argonaut presents an extraordinary deviation from the general laws which govern all other molluscous animals; inasmuch as the animal, although perfectly free and unattached to the shell it inhabits, is not now considered to be a mere parasite,*

* It is foreign to the present purpose to enter into the question as to the parasitism of the *Ocythoe*; the experiments of Madame Jeannette Power, confirmed to a great extent by the observations of M. Sander Rang and M. d'Orbigny, and more recently by those of Mr. Adams, during the voyage of H.M.S. Samarang, are generally considered as removing all doubt as to that animal being the fabricator of the shell in which it is found; and the theory of parasitism is now rejected by nearly all naturalists. A detailed account of the facts ascertained and recorded by Madame Power and M. Rang will be found in M. Rang's Mémoire, published in Guerin's 'Magasin de Zoologie,' and in Madame Power's 'Observations on the Poulpe of the Argonaut,' translations of which are published in the 'Mag. Nat. Hist.,' new series, vols. iii and iv. The observations of Mr. Adams, published in the 'Zoology of the Voyage of the Samarang,' tend to prove that the shell is constructed by the female Argonaut as a nest for receiving her eggs, and protecting them from injury, resembling in some measure the rudimental capsules secreted by many marine Gastropods for the preservation of the embryo. The animal firmly retains possession of this light calcareous shell-nest by means of the broad expanded membranes of the posterior pair of tentacles; but when disturbed or captured, she loosens her hold, and leaving her cradle to its fate, swims about independent of her shell. Having once deserted the nest, it appears that she has not the power, or more properly the sagacity, to re-enter it. Numbers of male Argonauts were taken by Mr. Adams, but always without shells. There are, however, in this theory, difficulties which probably future observation may explain. In the first place, the shells

†

as at first was supposed to be the case, but the actual fabricator of the shell; and it is believed that the broad membranes usually termed *vela* or *velamenta*, into which the extremities of the posterior pair of arms are expanded, and which usually envelope the shell, are the organs by which the deposition is effected; the mantle itself, apparently, not being capable of a calcifying secretion.

The beaks or *mandibles* with which the mouths of the Cephalopods are armed, vary in structure according to the habits of the animal. In the dibranchiate Cephalopod, whose principal food consists of fish, the mandibles are sharp, and entirely composed of horn; but, with the tetrabranchiate Cephalopods, the mandibles are blunt, and cased at their extremities with hard calcareous matter, adapted for the crushing of shells, and the defensive coverings of crustacea. The fossil substances called *Rhyncolites*, resembling the mandibles of the recent *Nautilus*, and found associated with the numerous chambered shells so abundant in the secondary and transition formations, appear to be remains of Ammonites, and the other cognate extinct genera by which those shells were inhabited.*

That the external chambered shells of the Cephalopods act in the same way as the swimming bladders of fish, and serve as floats, is obvious from the circumstance that, when deserted by the animal, they swim on the surface of the water. To an animal seeking protection against its enemies, by an instantaneous sinking in the sea, this tendency of the shell to float would prove a serious and dangerous impediment, if the animal itself did not possess the means, in some way or other, of increasing on the instant its specific gravity; and it has long been the opinion of naturalists that the siphuncle is subservient to this purpose, although a difference of opinion has prevailed as to the mode of operation. Dr. Hooke, so far back as the beginning of the last century, expressed an opinion that the *Nautilus* had the power of generating air to fill the deserted chambers, and that by the injection or exhaustion of this air through the siphuncle, the specific gravity of the shell could be diminished or increased. It is ascertained, however, that there is not any communication between the siphuncle and the empty chambers; and Mr. Parkinson, who, in his 'Outlines of Oryctology,' adopts an hypothesis similar to Dr. Hooke's, suggests that the tube is elastic and dilated by gaseous or aqueous fluids, the alternation of which produces a corresponding change in the specific gravity of the shell. Dr. Buckland

are found in different stages of growth, and they always exhibit the usual indications of successive periodic enlargements. Again, Mr. Adams states, "that it does not appear that the female is able to exist long when disengaged from the shell." How can these facts be reconciled with the theory that the shell is a mere *nidus?*

* MM. de Blainville and d'Orbigny have founded on these remains two genera, which they have named *Conchorhyncus* and *Rhyncoteuthis*. The reasons advanced for supposing that the *Rhyncolites* were not the mandibles of any of the Nautilidæ or Ammonitidæ already known, are far from conclusive; and these genera can only be regarded as arbitrary, though perhaps convenient, divisions, according to the peculiar forms presented by the remains.

maintains that a fluid is contained in the *pericardium*, the position of which is alternately changed from that cavity to the siphuncle; and that in this shifting fluid the hydraulic balance consists, the chambers being filled with air alone, the elasticity of which would admit of the alternate expansion and contraction of the membranous siphuncle. Prof. Owen has pointed out objections to both these hypotheses. The only organ apparently by which the gaseous fluids of Mr. Parkinson's theory can be secreted, is a small artery continued down the siphon, but which would not be adequate for the purpose; and the form and size of the siphon would not allow of an escape of gas so free as to make the consequent sinking of the shell sufficiently rapid for defensive purposes. In some extinct species of *Nautilus* the membranous siphuncle appears to have been capable of considerable dilatation, instances of which are mentioned by Dr. Buckland; but Professor Owen states that, in all the specimens he had examined, the membranous siphuncle, after the first chamber, presented an inextensible and almost friable texture, and was coated beyond the extremity of the testaceous siphon with a thin calcareous deposit; and that, in certain extinct species, the testaceous or calcareous siphon extended from septum to septum, rendering a dilatation of the membranous tube physically impossible. The calcareous siphon of the recent Spirula, as is well known, exhibits this form of structure. It is ascertained that, by the conversion of the dwelling-chambers of the animal into what may be termed air-chambers, the specific gravity of the Nautilus, and of its shell, may be maintained nearly in equilibrio with that of the sea. This equilibrium would be very sensibly affected by the position of the body of the animal with reference to the shell; and Professor Owen therefore inclines to the opinion* that the variation of the specific gravity is caused chiefly by changes in the extent of the surface exposed to the water, according as the body may be expanded beyond the aperture of the shell, or more or less withdrawn within the dwelling-chamber. At the same time it is not improbable that the siphuncle, filled with the fluid propelled into it from the pericardium, in consequence of the pressure caused by the contraction of the animal within the shell, may assist in affecting the specific gravity; it certainly, however, does not appear to be capable of varying the specific gravity of the shell sufficiently for the wants of the animal, and that function, if attributable to it, must consequently be merely secondary. I am therefore inclined to agree with M. d'Orbigny, who rejects the supposition that the action of the siphuncle is hydrostatic. That naturalist assigns to the membranous tube which enters the calcareous siphon, and communicates with the pericardial cavity, a function widely different, and only to be called into action when the animal constructs a new air-chamber. "On this occasion," he says, "many difficulties have to be overcome; the extremity of the body is attached above the last

* In this opinion M. de Blainville concurs (Mémoire sur l'Animal de la Spirula, &c.), and he shows that a similar mode is used by the Spirula; the alteration of the specific gravity being effected by the withdrawal of the cephalic mass into a cavity formed by the upper portion of the body.

septum (*en dessus de la dernière cloison*) by two powerful muscles; and the animal, always increasing in bulk, must detach its body, and remove and place itself at a determinate distance whenever it wishes to form a new partition. There must also be left, between the penultimate partition and that which the animal is about to construct, a space to be filled with air, while the animal is always under water." And M. d'Orbigny therefore suggests "that the membranous tube and pericardial cavity are required, when the new chamber is constructed, to empty the water contained in it, and to fill it with air before the siphon entirely closes its wall in the interior of the new air-chamber." This hypothesis does not appear to be more satisfactory than the one involving a hydrostatic function. No allusion is made in any way to the attachment of the animal to the shell by means of the *horny* or *epithelial cincture* which, as we have seen, encircles the lower part of the body. This cincture, in fact, hermetically closes the space between it and the last septum; and, unless it is detached, there would not be any external entrance through which the water could penetrate, and the function, the object of the hypothesis, becomes unnecessary. I cannot think therefore that this important attachment was overlooked; and I assume that M. d'Orbigny, when he says that the animal "must detach its body," means that it must detach not only the adherent muscles which he mentions, but also the horny cincture, to which he does not allude. Conceding this to be the case, then, the hypothesis in question assumes that the advance of the body, preparatory to the formation of the new partition, is not gradual; but that the animal, by sudden and nearly simultaneous efforts, detaches the adherent muscles and the cincture, and removes its body to the necessary distance. In all other testaceous molluscs, the advance of the adductor and adherent muscles is caused by the deposition of new matter, by means of a thin membrane, part of the pallial membrane, interposed between the extremity of the muscle and the inner surface of the shell. The deposition is made, particle by particle, on the anterior part of the muscle, portions of the posterior part probably becoming detached and absorbed; but this process is so gradual, that the attachment of the animal to the shell—an attachment, in fact, necessary to its existence—is not affected; and thus the muscle advances slowly and imperceptibly. There does not appear to be any reason for supposing that a law prevails among the cephalopodous molluscs different from that which regulates the advance of the adherent muscle in the testaceous gasteropod. We may readily conceive, on the contrary, that the entire detachment of the muscles and of the cincture would be attended with considerable inconvenience to the animal; for, in that condition, the fulcrum or resisting power by which the animal is enabled to use its tentacles and other organs efficiently, and which is essential to its existence, would be temporarily lost. The sudden removal of the body forward would probably, although it cannot be assumed that it would necessarily, cause the rupture of the membranous siphon, for that organ may be sufficiently elastic to stretch to the required

distance; but the rupture is, in fact, required by the hypothesis, and the animal would thus be deprived at once of all its means of attachment to the shell. Neither by this periodic advance would the equilibrium of the specific gravity be maintained. We are warranted, I think, in assuming that the specific gravity of the animal and its shell, without the siphuncular aid, would be most nearly in equilibrio with that of the surrounding sea immediately after the formation of a new septum. Now the growth of the animal would constantly tend to derange this equilibrium, until the period should arrive for the formation of the new septum. The capability of the animal, therefore, to rise and sink would be as constantly fluctuating, unless there existed some mode of compensating for the increasing bulk of the body during the interval between the formation of the penultimate septum and that of the last. This compensation, however, would be provided in the case of a gradual advance of the line of attachment; for the vacated part of the dwelling-chamber, filled with exhalations from the animal, and increasing in size as the body is advanced, would become an air-chamber as effective as if it were inclosed by a new septum; while, on the other hand, a periodic advance of the muscles and cincture would deprive the animal of this mode of maintaining the equilibrium.

I have mentioned the rupture of the membranous tube, which would be the consequence of the sudden advance of the body; in fact, the hypothesis which attributes to this tube the function of carrying off the water admitted into the vacated part of the shell by the detachment of the cincture, requires, *ex necessitate*, that the tube should be ruptured in order that the water should enter it; and in that case the membranous siphon in the deserted chambers would consist of detached fragments extending from septum to septum, and which, having fulfilled their object and become severed from the animal, would no longer retain vitality. This, however, is not the fact. The membranous tube is continued entire through all the septa to the extreme air-chamber,* and is a vascular organized substance, provided with an artery and a vein for its nutrition; and it maintains its vitality during the life of the animal. We are compelled, therefore, to think that the function of the siphuncle must be coextensive with the animal's existence. On these grounds, the theory suggested by M. d'Orbigny is not more satisfactory than the hydrostatic theory which he rejects. Whatever the function may be, it is evident that the air-chambers themselves would be as efficient a float without the siphon as with it; and the alteration of the specific gravity, as has been stated, may and in all probability is, effected simply by the animal protruding or withdrawing the cephalic mass from or into the dwelling-chamber of the shell, or, as

* Professor Owen, speaking of the specimen of *Spirula Peronii* (*fragilis*), brought home by Sir Edward Belcher, says: "On gently raising the exposed portion of the siphon with a needle, the soft siphon was withdrawn, without sensible resistance, from the tube of the hard siphon; the siphon so withdrawn must have reached nearly to the innermost whorl. It exhibited a slight segmentation, answering to the successively sheathed parts of the calcareous siphon."

M. de Blainville has shown to be the case in Spirula, within a cavity formed by the anterior extremity of the mantle. We may reasonably infer, therefore, that to assist in varying the specific gravity is not the principal function of the siphuncle. But, in any view, the preservation of the deserted chambers, as air-chambers, is essential to the motive power of the animal; for it is only by their tendency to float when the cephalic mass is protruded, that the animal is enabled to rise; and this nicely-adjusted counterpoise is maintained, as we have seen, by the addition of new air-chambers, as the animal and the shell increase in size. It is obvious, therefore, that the hydrostatic balance would be destroyed if any one of the deserted chambers were so injured as no longer to act as a float. Now it is known that the shells of the testaceous molluscs are not wholly inorganic substances; but that a vital communication is maintained between them and the animals, and that where this communication ceases, the deserted whorls of the shell lose their vitality and become brittle; the calcareous matter falls off in particles, and the shell is much more susceptible of injury. In *Bulimus decollatus* (*Helix decollata*, Linn.) and other similar shells, in which the earlier whorls are wholly deserted, the animal on withdrawing its body forms behind its extremity a concave septum. In these cases the apex of the shell, no longer necessary, is easily broken off; in which state the shell is said to be *decollated*.* In the siphoniferous shells, however, the preservation of the chambers, as air-chambers, is, as we have already seen, essential to the motive power of the animal. It is true that in the Nautilus, the mode of convolution, upon a vertical axis, is admirably adapted to strengthen and protect the first-formed volutions; but in shells not so constructed, and even in those possessing the nautiliform mode of convolution, it would appear to be essential that the vitality should not be lost. How, then, is the necessary communication between the animal and the air-chambers maintained, and the vitality of the deserted shell preserved? It has been shown that the siphuncle traverses the chambers to the extreme nucleus of the shell, and that it is provided with a small artery and vein; and we also learn from Professor Owen's Memoir, that in the Nautilus "a delicate pellicle, distinct from the tube, is continued over the outer part of the testaceous tube, and also over the whole inner surface of the chamber." May we not then reasonably regard the siphuncle with its artery and vein, and the pellicle lining the air-chambers, as the organs destined to maintain the vitality of the shell, and feel ourselves justified in considering this office to be in fact the primary function of the siphuncle? And when we bear in mind that the internal shells, from

* I am wholly indebted to my friend Mr. Searles Wood for the following theory as to the siphuncular function, and the main arguments in support of it. The well-known conchological attainments of that gentleman exact respect for every opinion of his on subjects like the present; but independently of this, the theory itself seems to me to be far more probable than any hitherto advanced as to the office of the siphon; and I therefore gladly avail myself of Mr. Wood's permission to introduce his views of the subject into my text.

their terminal or, as in Spirula, their exposed position, are particularly liable to injury from the shocks caused by the retrogressive movements of the animals, we shall find that the hypothesis will be as applicable to them as to the external shells. In the extended series of observations made by Dr. Carpenter upon the microscopic structure of shells, it is shown by that gentleman that the outer covering or shelly mass of molluscous animals is invariably permeated by an organized membrane, and he says (Report Brit. Assoc., 1844, page 9): "I am much disposed to believe that in every distinct formation of shell substance there is a single layer of membrane, and I am further of opinion that this membrane was at one time a constituent part of the mantle of the mollusc." He further represents this membrane to have, more or less, a cellular arrangement, the interstices of which are filled with carbonate of lime or inorganic matter; and, at page 10, he says: "Coupling the appearances which I have myself observed, with the observations of Mr. Bowerbank, on the formation of shell, and keeping in view the general doctrines of cell action which I have elsewhere endeavoured to develope, I am inclined to believe that these cells are the real agents in the production of the shell, it being their office to secrete into their own cavities the carbonate of lime supplied by the fluids of the animal." He does not appear to have extended his researches so far as to determine whether any or what amount of vitality is possessed by these membranes; but from the continuity and intimate connexion of this beautiful network, permeating the entire substance of the shell, we may imagine that some slight degree of vital existence pervades the whole membrane, by which it is possible that the inorganic material is preserved from disintegration. In those shells which appear to have been subject to the erosive action of acidulated waters, or other external agency, such as the apices of *Cerithia* and the umbones of *Cyrenæ*, the part most affected is that which is furthest removed from the main body of the animal; while that part of the shell which is in close proximity with the mantle is not, or at least but little, altered; probably owing to its greater vitality, and to its being the part most essential for the protection of the animal. Not only is the entire formation of shelly matter permeated by an organic membrane, but in some of the shelly coverings of molluscous animals in the order *Brachiopoda*, there is a very peculiar structure, somewhat analogous with what has been before suggested as the especial use of the siphuncular tube in the Cephalopoda. Dr. Carpenter has pointed out that in most, or perhaps in all, of the nonplicated species of Terebratula, the whole surface of the shell is perforated with innumerable pores, into which are inserted vascular portions of the mantle of the animal, of a tubular form, and filled with fluid, which have no communication with the exterior, but are closed at the outer surface of the shell, and occupy the entire space of the pores. These cæcal appendages may be for the purpose of distributing a greater degree of vitality through the body of the shell; though for what especial purpose this provision is required in one group more than another, it is not easy to explain; perhaps a greater degree of strength is

required in the *nonplicated* shell, for the preservation of an animal, whose habitation, for the most part, is at a considerable depth, where the pressure of water is much increased, than in the plicated species, the peculiar construction of which would afford sufficient resistance, without that additional support which the smoother species may receive from this singular structure of the mantle. If, however, a necessity exist for the preservation of the shell in ordinary cases, how much more essential would it be that some compensating power should be possessed by an animal whose existence, in all probability, is dependent upon the buoyant principle of its partitioned shell; and how probable does it appear that this, an ordinary provision, should be employed for its protection.

The tubular character of the siphuncle suggests an hydraulic action. To explain this, it is necessary to invest the animal with the power of emptying and filling the tube at discretion; and this power it may be presumed to derive from the pressure upon the pericardial cavity, caused by the folding and contracting within the shell of the large cephalic mass. Under this pressure the fluid would be injected the whole length of the siphuncle, and, on the removal of the pressure, would return into the pericardium, to be there renovated and vivified with the other fluids, to be again injected when the animal returns within the shell. If the siphuncle had been a solid body, or composed of muscles, fibres, &c., it would have required to be permeated with arteries, blood-vessels, &c., for its sustenance; but by the simple process of the fluid returning into the body of the animal, all the complicated apparatus necessary to sustain a fleshy body is superseded; circulation and renovation are accomplished, and the fluid is thus maintained in a condition capable of affording the nourishment to the shell which the present hypothesis requires.

The theories here suggested are, as all other theories on the same subject must for the present be, merely speculative; for, to quote the observation of Professor Owen,* "much remains to be done before the theory of the chambers and siphuncle can rest on the sound basis of experiment and observation." These alone will satisfactorily determine the real purposes of the membranous siphuncle; but, for my own part, I believe that the primary, and probably the only, function of that organ is to maintain the vitality of the shell, and that it may be looked upon as an elongated cæcum; and that it is not, under any circumstances, used by the animal as a hydrostatic balance.

It is unnecessary here to particularise the various forms of external shells presented by the extinct tetrabranchiate Cephalopods, inasmuch as, of the numerous genera which swarmed in the ancient seas, only the Nautilus survived the secondary period.

The dibranchiate Cephalopods, with the exception of the genus *Argonauta* (which, with *Bellerophon*, constitutes Professor Owen's family of testaceous Octopods), are without

* Memoir on the Nautilus Pompilius, p. 47.

external shells; but they are provided with internal horny or calcareous substances, encysted in the back of the mantle, and frequently not in any way attached to the animal, but loose in the cells containing them. In the naked Octopods these internal substances are of the simplest form, and consist of two short, horny, gelatinous styles. Among the Decapods, they become gradually more complicated in structure. In the *Loligidæ*, the *Loligopsidæ*, and the *Teuthidæ*, they assume the form of a horny plate, termed the *gladius*, which in some genera is thin and feather-shaped, or more or less spatulate, lanceolate, or ensiform; and in others, they are elongated, narrow, and terminated posteriorily by a simple cup-shaped appendage. In the *Sepidæ* the shell presents a series of thin calcareous plates, not siphoniferous, but separated by numerous exceedingly minute pillars, and forming a convex mass terminated by a *mucro* or spine; in the *Belemnitidæ* it consists of a chambered cone perforated by a siphuncle, and lodged in a cavity formed in the upper portion of a calcareous rostrum, more or less pointed or obtuse; and in the *Spirulidæ*, the sole remaining family, it is a calcareous, horizontally convolute, multilocular, and siphonated shell, with distinct whorls, and imbedded in the animal, but having portions of the last whorl merely covered by the outer layers of the skin. These differences in structure appear to be always accompanied with distinct zoological forms; and hence the Palæontologist is enabled to form a tolerably correct judgment of the analogy between the existing species and those which inhabited the ancient seas, although the testaceous remains are, most frequently, the only means of comparison afforded to him.

These internal shells are formed by secretions, from the internal surfaces of the cells, of a horny or calcareous substance, which is deposited in successive layers, and by the continual addition of which they increase in size as the growth of the animal proceeds. Their functions are various, and in accordance with their particular structure. When the internal shell is gelatinous or horny, as in the Octopoda, and in the *Loligidæ*, *Loligopsidæ*, and *Teuthidæ*, the function is chiefly to support and strengthen the body, analogous with that of the bones in the vertebrate animals. It appears that the greater or less length of the shell has always relation to the swimming power of the animal. When the internal shell is horny or calcareous, and contains parts filled with air, as is the case in the several other decapodous families, it acts as a float; and in this function, like the external shell of the tetrabranchiate Cephalopods, it represents the swimming bladder of fish; but the volume of air contained within the shell is, apparently, in an inverse ratio with the swimming power of the animal. In addition to these functions, the internal shells, which are provided with a mucro or rostrum at their posterior extremities, as in the *Sepidæ* and *Belemnitidæ*, are enabled by its means to break the force of the shocks caused by the body striking against any hard substance in its retrograde motion. In the recent Cephalopods this protection is confined to the *Sepidæ*, the most littoral of all the Cephalopods: to the deep-sea swimmers it is denied; it would in fact be

useless to them. We may assume, therefore, that in the extinct Cephalopods the presence of the mucro or rostrum will indicate a littoral animal. M. d'Orbigny states that he has always observed in the Sepia, the extremity of the mucro projecting beyond the body, and it is not improbable that this part of the shell may be used, as he suggests, for defensive purposes, and that it is protruded at the will of the animal.

The Cephalopods, highly organized as they are in comparison with the other molluscs, are among the earliest forms of animal life which geology has brought to light. The Silurian group, the most ancient fossiliferous formations with which we are acquainted, contains the remains of one species of Nautilus, and of many species belonging to cognate genera. Several species of Goniatites, an anomalous genus belonging to the *Ammonitidæ*, and connecting that family with the *Nautilidæ*, also occur. As we ascend in the Palæozoic series, we find that various of the primitive genera and species disappear, and are succeeded by other forms, distinct from, although closely allied to, them; which, in their turn, are also lost. On passing into the Mesozoic series a marked change takes place. Of the eight genera constituting the family *Nautilidæ*, which lived during the Palæozoic epoch, Orthoceras* and Nautilus alone survive; and of the long series of species belonging to the latter genus, whose remains are found in the carboniferous formations, every one disappears; but an immense array of Ammonites starts into existence, with septa at first comparatively simple, but becoming more complicated in structure in the succeeding formations. The dibranchiate Cephalopods now first appear.† In the Oolitic group, twenty-five species of Belemnite, and remains of various genera belonging to the families *Loligidæ* and *Teuthidæ*, have been found. The Belemnites occur in incredible quantities, and sometimes form entire strata. Passing into the Cretaceous group, we still find the Nautilus, though of diminished importance; the Ammonites are reduced in number to little more than a fourth part of the species found in the Oolitic group, and new modes of convolution appear in their shells, on which the several other genera constituting the family *Ammonitidæ* are founded. The family itself gradually diminishes as we ascend in the Cretaceous group, and wholly disappears with the secondary period. The Belemnites appear to be the sole representatives of the dibranchiate Cephalopods during this epoch, and with it they also perish. On entering into the tertiary formations we find, that of the rich and varied assemblage of tetrabranchiate Cephalopods which characterised the fauna of the secondary period, only the *Nautili* survived. On the Continent their remains are found in the Eocene formations, and also in the Miocene formations, at Turin and in Touraine; but in this country they are confined to the older Eocene deposits. Of

* Von Hauer (Neue Cephalopoden aus dem rothen Marmor von Aussee), describes several Orthoceratites associated with Goniatites in the schistose beds of St. Cassian; those beds, I believe, are now generally considered to belong to the Muschelkalk.

† The remains described by Goldfuss and Bronn as *Spirulæ*, appear to belong to Gyroceras, a genus of the *Nautilidæ*.

the dibranchiate Cephalopods, two species of Argonaut have been found in the newer tertiary formations on the Continent; and two genera belonging to the family *Belemnitidæ* occur in the beds of the Paris basin, and in the Eocene formations of England. The remains of one of these last are very closely allied to the recent Sepia, and have been generally referred to that genus. M. Voltz, in his 'Observations sur les Bélemnites,' pointed out certain differences which induced him to propose a new genus, named by him "Belosepia," for their reception. The French Palæontologists reject this genus as having been proposed on insufficient grounds; but, for the reasons stated in a subsequent part, it ought, as it appears to me, to be retained. The other remains found in the Paris basin, connect Belosepia with Belemnite; and the genus *Beloptera* has been established by M. Deshayes for their reception. Both these genera occur in the London clay and in the Bracklesham sands; and they, together with certain remains found in the neighbourhood of London, and described by Mr. James Sowerby in the Mineral Conchology as *Beloptera anomala*, and for the reception of which I have proposed the new genus *Belemnosis*, are the only remains of dibranchiate Cephalopods which as yet have been found in the tertiary formations of England.

That these animals fulfilled in the ancient seas the office of repressing animal life cannot be doubted. The living Cephalopods are voracious in the extreme; and, as we find that throughout the transition and secondary groups the number of the zoophagous Trachelipods is small in comparison with that of the phytophagous Mollusca, it is not unreasonable to seek in the Cephalopods for that check upon an excessive increase of submarine life, which the other zoophagous molluscs were too inconsiderable in number to afford.*

There is scarcely any class in the animal kingdom of the anatomy and habits of which zoologists have so long remained ignorant, or of which the systematic arrangements proposed have been so conflicting as the class Cephalopoda. Composed, as it is, of animals in their external construction and appearance remote from all others, and widely differing among themselves, we need not feel surprised at the confusion which characterises the older systems, based, as they all were, more or less, on artificial characters, derived from the various conditions of the shell, or from modifications of the dermal system; and the confusion was increased by the introduction among the Cephalopods of numerous microscopic chambered shells, to which M. d'Orbigny gave the name *Foraminifera*, but which the recent investigations of Dujardin show to have been constructed by an inferior class of animals, belonging or allied to the Zoophyta, and which he has named *Rhizopoda*. It would be foreign to the purpose to enter here into any history or comparison of the different systems of arrangement which have been proposed. In the eleventh volume of Lamarck's 'Histoire Naturelle des animaux sans vertèbres,' edited by MM. Deshayes and Milne Edwards the reader

* See Dr. Buckland's Bridgewater Treatise, vol. i, chap. xv.

will find a most comprehensive and able review of the progress of this branch of natural history.

The principle of classification adopted by Cuvier removed many of the difficulties and inconsistencies which had previously prevailed; but it was still based, to a great extent, on external characters. Attempts at arrangements, founded on higher characters, were made by different authors; but the imperfect knowledge which existed of the anatomy of the animals, prevented the establishment of a system in which due regard could be paid to affinities indicated by internal organization. Of late years, however, considerable additions have been made to our knowledge of the anatomy of these animals; and in 1830, the arrival in this country of a specimen of the pearly Nautilus, caught off the coast of one of the New Hebrides, enabled Professor Owen to examine the internal structure of that animal, an opportunity which had not occurred to naturalists since the time of Rumphius. The anatomy of various other Cephalopods was also investigated by Professor Owen; and the additional information thus obtained, led that gentleman, in 1836, to propose a system of classification which, although at variance in many respects with all previous arrangements, was at once received as one founded, in its general principles, on well-defined and natural characters; and this system, accordingly, forms the basis of the more recent classifications.*

All the Cephalopods the anatomy of which had been examined previously to the arrival of the pearly Nautilus, respired by the agency of two branchiæ or gills, and possessed three hearts, a systemic heart, and two lateral hearts; they were also endowed with eight arms furnished with suckers, some genera having also two elongated tentacula or additional arms. The pearly Nautilus, however, was found to be possessed of four branchiæ, and of only one heart; and, instead of arms, the mouth of the animal was surrounded by numerous short tentacula. Availing himself of these natural and well-defined characters, Professor Owen divided the Cephalopoda into two orders: 1st, *Dibranchiata*, comprising those furnished with two gills; and 2d, *Tetrabranchiata*, comprising those furnished with four gills. The Dibranchiata were subdivided into two sub-orders or tribes, according to the number and condition of their locomotive organs; the first tribe (Octopoda) consisting of the Cephalopods with eight arms, having the suckers simple, and the branchial chamber divided by a diaphragm; the second tribe (Decapoda) consisting of those Cephalopods possessed

* Up to this time Spirula, as well as Belemnites, had been classed with Nautilus, and the other Cephalopods which now form the tetrabranchiate order (*Ceph. test. polythalamaces* of Lam.; *Siphoniferes* of D'Orb.) Of the anatomy of the animal nothing was known; but the presence of an ink-bag, and the acetabuliferous character of the arms had been shown by Lamarck and Peron; and from this fact Professor Owen, aided by that knowledge of the laws of correlation which imparts such value to all his observations, inferred that the animal must present the dibranchiate type of structure. The accuracy of this deduction is now fully established.

of eight arms, and two additional elongated tentacula. In this tribe the suckers are armed, and the mantle supports two lateral or terminal fins. The "*Octopoda*" were divided into two families, termed "*Nuda*" and "*Testacea*," according to the absence or presence of an external shell. In the second family was placed *Bellerophon*, an extinct genus proposed by De Montfort for remains peculiar to the Palæozoic series, which Defrance had associated with Argonaut, but which subsequently had been considered as belonging to a heteropodous mollusc. The reasons which induced Professor Owen to restore *Bellerophon* to a place among the Cephalopods are not stated. If however, its remains belong to this class, they present the anomaly of the testaceous Octopods having been without a representative from the end of the carboniferous epoch until the deposit of the newer tertiary formations, when the family reappears in the genus Argonaut. The decapodous Cephalopods were divided into four families, according to the position of the fins, the nature of the internal shell, and the condition of the infundibular cartilage. The ordinal and sub-ordinal distinctions of Professor Owen have been adopted by M. Deshayes, but that naturalist has subdivided the Octopoda and Decapoda each into two groups; the Octopoda according to their possessing one or two rows of suckers, and the Decapoda according to the position of the fins. These characters appear to be of secondary importance, and, by themselves, can scarcely be considered as sufficient for more than generic distinctions. M. d'Orbigny has availed himself of the presence of suckers and tentacles, characters originally proposed by himself and M. Ferussac as ordinal distinctions, and accordingly the Cephalopoda are divided by him into *Acetabulifera* and *Tentaculifera*. The sub-ordinal distinctions of Professor Owen are adopted by this author; but in his subdivision of Octopoda he has drawn his characters from the presence or absence of the apparatus for resistance, and the aquiferous pores. The Decapoda are arranged by him in two groups, according to the modification in the structure of their eyes, to which I have before alluded. The first group (*Myopsidæ*) is divided into three families. In two of these, *Sepidæ* and *Loligidæ*, the characters are taken from the retractile power of the tentacular arms, the condition of the internal shell, and the presence or absence of an eyelid of a part of the auditory apparatus called by him the auricular crests (crêtes auriculaires), and of a superior ligament to the funnel; the character of the third family (*Spirulidæ*) rests entirely on the internal shell. The second group (*Oigopsidæ*) also consists of three families, two of which, *Loligopsidæ* and *Teuthidæ*, depend on the presence or absence of a lachrymal sinus and the auricular crests, on the funnel being or not being provided with an internal valve and ligaments, on the condition of the aquiferous pores, and on the shell being with or without air-chambers. The *Belemnitidæ*, the third family, is separated entirely by the character of the internal shell.

The peculiar modifications in the structure of the eyes among the decapodous Cephalopods appear to be of sufficient importance to justify the subdivision of that sub-order into the two groups proposed by M. d'Orbigny; and inasmuch as the adoption

of that division involves the distribution of the genera forming Professor Owen's extensive family *Teuthidæ* between the two groups, and the characters on which M. d'Orbigny has formed his families are at the least of equal importance with those used by Professor Owen, I have adopted the classification proposed by M. d'Orbigny, but with the following modification. That author has placed *Beloptera* and *Spirulirostra* among the *Spirulidæ*. Now the shells of these genera present a series of siphonated air-chambers associated with a rostrum, and therefore bear a much closer affinity with *Belemnite* than with the shell of the recent Spirula. I have, therefore, placed them, as well as *Belemnosis*, among the *Belemnitidæ;* and as I agree with Voltz in considering *Belosepia* to have possessed a camerated and siphoniferous shell, I have also placed that genus in the same family, notwithstanding the close affinity between its remains and the internal shell of the recent Sepia.

- MOLLUSCA
  - CEPHALOPODA.
    - Dibranchiata (Acetabulifera; *Fer. et d'Orb.*)
      - Octopoda
        - Octopidæ
          - Eledone.
          - Octopus.
          - Pinnoctopus.
          - Cirroteuthis.
        - Philonexidæ
          - Philonexis.
          - Argonauta.
      - Decapoda
        - Myopsidæ
          - Sepidæ
            - Cranchia.
            - Sepiola.
            - Sepioloidea.
            - Rossia.
            - Sepia.
          - Spirulidæ
            - Spirula.
          - Loligidæ
            - Loligo.
            - Sepioteuthis.
            - Teudopsis.
            - Leptoteuthis.
            - Beloteuthis.
        - Oigopsidæ
          - Loligopsidæ
            - Loligopsis.
            - Chiroteuthis.
            - Histioteuthis.
          - Teuthidæ
            - Onychoteuthis.
            - Enoploteuthis.
            - Kelæno (Acanthoteuthis, *Wagn.*)
            - Ommastrephia.
            - Belemnosepia *Agaz.* (Geoteuthis, *Muns.*)
          - Belemnitidæ
            - Belosepia.
            - Beloptera.
            - Belemnosis.
            - Spirulirostra.
            - Conoteuthis.
            - Belemnoteuthis.
            - Belemnitella.
            - Belemnites.
    - Tetrabranchiata. (Siphonifera; *Fer. et d'Orb.* Tentaculifera; *d'Orb.*)
      - Nautilidæ
        - Nautilus.
        - Planulites (*Lam*).
        - Gyroceras.
        - Lituitus.
        - Campulites, *Desh.* (Cyrtoceras, *Goldf.*)
        - Phragmoceras.
        - Orthoceras.
        - Actinoceras.
        - Koleoceras (*Portl*).
        - Poterioceras *M'Coy* (Gomphoceras, *Sow.*)
      - Clymenidæ
        - Aturia.
        - Clymenia.
      - Ammonitidæ
        - Turrilites.
        - Helioceras.
        - Goniatites.
        - Ammonites.
        - Crioceras.
        - Scaphites.
        - Ancyloceras.
        - Hamites.
        - Toxoceras.
        - Ptychoceras.
        - Baculites.

ORDER—*DIBRANCHIATA.* SUB-ORDER—*DECAPODA.*

Tribe—OIGOPSIDÆ.

1*st Family*—BELEMNITIDÆ.

The *Belemnitidæ*, the sixth family in the classification proposed by M. d'Orbigny, consist, according to that author, of the genera in which the animal was provided with an internal horny or calcareous shell, having at the *posterior part* air-chambers superimposed in a nearly straight line in the form of a cone, and pierced on the ventral part by a marginal syphon. The family is confined, according to that author, to the three extinct genera, *Conoteuthis*, *Belemnitella*, and *Belemnites*.

The two latter genera, however, do not appear to fall strictly within the terms of the definition; for the posterior parts of their shells consist, as is well known, of a spathose guard, frequently of considerable size, the anterior extremity of which is produced so as to form an alveolus for the reception of the phragmocone. If, as the fact is, the genus *Belemnites* forms the typical genus of the *Belemnitidæ*, it would surely be proper that those genera which, like the type, possess camerated siphoniferous shells, terminated posteriorily by a calcareous guard, should, at all events, be included in the family. It is difficult therefore to conceive on what sound principle *Spirulirostra* and *Beloptera*, but more particularly the last genus, whose calcareous remains present so striking a resemblance to those of *Belemnites*, instead of being placed in this family, have been associated with *Spirula*, with whose spiral discoidal shell they present so little analogy.

It appears to be desirable that, for the present at least, the Belemnitidæ should be extended so as to comprise all the genera in which the animal possessed an internal horny or calcareous shell, with or without a terminal guard, but containing air-chambers pierced by a ventral siphuncle; whether those chambers were superimposed in a nearly straight line in the form of a cone, or in a spiral or subspiral line. As thus enlarged, the Belemnitidæ will consist of the following genera: Belosepia, Beloptera, Belemnosis, Spirulirostra, Conoteuthis, Belemnoteuthis, Belemnitella, and Belemnites.

Hereafter it may be desirable to form a division for the reception of genera in which, as in Conoteuthis, the apex of the sheath is simple.

All attempts at a linear arrangement are absolutely futile; but it will be seen that in this, as in every case where several genera are grouped together, the family presents aberrant forms leading to other groups; thus *Beloptera*, *Belemnosis*, and *Belosepia*, leading to *Sepidæ*; *Belosepia* and *Spirulirostra* to *Spirulidæ*; and *Conoteuthis* to *Teuthidæ*.

Genus 1*st*. BELOSEPIA.* *Voltz*. 1830.

SEPIA. *Cuvier; Férussac; d'Orbigny; Deshayes.*

BELOSEPIA. *Bronn.*

Animal unknown; but, from the affinities between its calcareous remains and the internal shell of the recent Sepia, supposed to have more nearly resembled that genus than any other existing Cephalopod, and may be thus described:

Body oblong, (?) naked, supporting two lateral fins extending its whole length; *mouth* terminal, furnished with two corneous mandibles, and surrounded by ten prehensile acetabuliferous arms, of which two were longer than the others; *mantle* free at the anterior margin; *branchiæ* two.

Shell internal, oblong, semiconical, coarsely granulated or sulcated on the exterior, internally smooth, containing a series of transverse laminæ, perforated near their ventral margins by large elliptical, sub-siphoniform openings, and terminating in a solid beak or rostrum, inflected towards the dorsal aspect, and expanded at the anterior extremity on the dorsal aspect into an elevated callus, and on the ventral aspect into a semicircular plate bent outwards over the base of the rostrum; the ventral margins of the laminæ converging towards the anterior extremity of the rostrum, and connected by a thin calcareous plate.

Testâ internâ, oblongâ, semiconicâ, externè granulatâ, internè lævigatâ; septa transversa, foraminibus ventralibus ellipticis subsiphonoidis perforata, continenti, et rostro solido, anticè, parte dorsali in callum proeminentem, parte ventrali in laminam supra rostrum reflexam dilatato, posticè sursum inflexo, terminatâ; septorum marginibus ventralibus ad basim rostri convergentibus et tenui laminâ connexis.

The remains of this extinct Cephalopod have been long known as of frequent occurrence in the Paris basin; they were noticed by Guettard† and were described by him as the fossil teeth of sharks. They were also figured by Burtin,‡ and by him were considered to be internal bones of a fish's head. To Cuvier palæontology is indebted for pointing out their true character. In a short notice published in 1824, in the 'Annales des Sciences Naturelles,' that illustrious naturalist referred the remains in question to a cephalopodous mollusc closely allied to the recent Sepia; and, in fact, they, as well as the remains of another extinct Cephalopod which exhibited an unquestionably camerated and siphoniferous structure, and for the reception of which the genus *Beloptera* had been established by M. Deshayes, were placed by M. d'Orbigny in that genus. M. de Blainville also in the first instance described them as the remains of a Sepia; but afterwards, when he adopted the genus Beloptera for the *Sepia*

* Etym. Βελος, telum; Σηπία, sepia.

† Mémoires sur différentes parties des Sciences et Arts, 1783, Septième Mémoire, pl. 2, figs. 29-30.

‡ Oryctyographie de Bruxelles (1784), pl. 2, fig. A.

Parisiensis, he confounded with it the remains in question. M. Voltz was the first to examine these remains with the attention they deserve. This author instituted a comparison between the shell of the *Beloptera Belemnitoidea*, that of the *Beloptera Sepioidea* (Sepia Parisiensis), and the recent *Sepion*, and stated the reasons which induced him to consider the *Beloptera Sepioidea* as belonging to a distinct genus, equally removed from the *Beloptera Belemnitoidea* and the recent *Sepia*, and as forming a natural connexion between *Belemnites* and *Sepia;* and he proposed the present genus, *Belosepia*, for its reception. The principal ground advanced by him to justify this separation was, that the remains of Belosepia indicated a camerated and siphoniferous structure in the contents of the sheath, widely different from that of the Sepion; and, if this opinion be correct, there cannot be a doubt as to the propriety of the separation. M. Deshayes, however, in his 'Description des Coquilles fossiles des Environs de Paris,' without questioning in any respect the accuracy of M. Voltz's description, without referring even to that author's opinion as to the siphoniferous structure of the shell, but simply relying on the analogy drawn from the general resemblance between the remains of the *Sepia Parisiensis* and the *Sepion*, unhesitatingly rejected the genus Belosepia as not possessing characters sufficiently distinct from those of *Sepia;* although he considered that it would be desirable to form a section in the genus Sepia for the reception of the fossil species. In this opinion M. Deshayes has been followed by MM. Pictet and d'Orbigny. I cannot concur with these authors in the rejection of M. Voltz's genus. The Belosepion* appears to me to present peculiarities of structure, indicating corresponding important zoological differences, which render it impossible to regard the animal to which it belonged as forming part of the existing genus Sepia.

The Belosepion, like the internal shell of the Sepia, is a compound shell, and consists of—1st, a solid calcareous mucro, or rostrum, commonly called *the beak*, inflected at the posterior extremity towards the dorsal aspect, and at the base expanding on the dorsal aspect into an elevated, compressed, and more or less rugose mass, called by M. Deshayes the *callus*, and on the ventral aspect into a thick semicircular plate, bent outwards, in a radiated fold, over, but not touching, the upper portion of the rostrum, denticulated on the margin, and continued laterally into the parietes of the sheath.

2d. An inverted semiconical calcareous plate, termed the *sheath*, externally coarsely granulated, internally smooth, but presenting a series of undulating impressions, converging towards the inverted apex, where the sheath terminates in a conical cavity, formed in the anterior portion of the rostrum, and strongly inflected towards the ventral aspect, so that the posterior extremity presses against the origin of the radiated fold.

* The term *Belosepion* is used here to describe the entire internal shell of the *Belosepia;* in the same way as the term *Sepion* (*Sepiostaire* of De Blainville) is used by English writers to describe the internal shell of the *Sepia*, or what is usually known as "Cuttlefish-bone."

3d. A thin calcareous layer, covering the whole of the inner surface and the terminal cavity of the sheath; and

4th. A series of thin laminæ or septa imposed one upon another, at first nearly vertically, but assuming gradually a horizontal direction, owing to the convergence, towards the origin of the radiated fold, of their ventral margins, which are nearly straight, and connected by a calcareous plate, forming the ventral surface of the sheath.

The undulating impressions which appear within the sheath are strongly defined on the dorsal aspect, but become faint as they approach the ventral surface. M. Voltz has described these undulations as impressions of the sutures of the *alveolus*;* while, on the other hand, M. d'Orbigny considers them to be lines of growth, and not marks of the chambers, which, he says, in fact only occupied one half of the cavity. They are, however, strictly analogous with the similar impressions found in the *Sepion*, and are formed by the margins of the laminæ or septa. Being formed in succession as the new laminæ are added, it is true that in that way they represent the progressive increase of the shell; but they are not true lines of growth.

The extreme fragility of the laminæ has not allowed of their preservation; but their remains occur, not unfrequently, towards the posterior extremity of the sheath, consisting of fine elevated lines, which traverse the whole circumference of the cavity, and are, in fact, the dorsal and lateral margins of the laminæ adhering to the inner sheath. These lines are continued over the calcareous plate, which connects the ventral margins of the laminæ; and it is evident, therefore, that the laminæ extended across the whole of the transverse area of the sheath.

The ventral margins are always convergent towards the origin of the radiated fold; and, consequently, the laminæ within the terminal cavity slant in a direction opposite to that of the laminæ within the sheath, inasmuch as that the cavity extends wholly below the origin of the fold. Owing to this, the arrangement of the chambers formed by the septa somewhat resembles that of the air-chambers in *Spirulirostra*, except that in the latter shell the plane of the septa is always at right angles with the axis; while in the *Belosepion* it is at an angle more or less acute as the septa approach to, or recede from, the point of convergence. In the cavity itself, the dorsal margins of the laminæ are distant; but as they approach that part of the sheath which is immediately under the point of convergence, they are placed more closely to each other, and they again become distant as the laminæ emerge from the cavity. Owing to the convergence of their ventral margins, the laminæ, which as they emerge are nearly vertical, take a direction gradually more and more slanting towards the anterior extremity of the rostrum, until, on the shell attaining its full growth, they assume a position nearly

* The word *alveolus* is used by this author in its original meaning, and is applied to the chambered cone which Professor Owen has named the *phragmocone*. The term *alveolus* has been with greater propriety restricted by the latter gentleman to the cavity in which the *phragmocone* was lodged.

horizontal. This arrangement of the laminæ is well displayed in fig. 1*k*, Tab. I, drawn from a specimen found at Sheppy, for the use of which I am indebted to Mr. Dixon, to whom it belongs. The ventral margins of the laminæ extend quite across the connecting plate before mentioned; and on each side, at a short distance from the extremities, they expand into the lateral portions of the laminæ, small projecting fragments of which are sometimes still found adhering to the sides of the sheath. It is evident from this that the opinion expressed by M. Voltz, that there existed in each of the laminæ an opening placed near the ventral margin, is correct. These openings appear to have been of an elliptical form, with their shorter axes in a line from the ventral to the dorsal surface, and were lined with an extremely thin calcareous sheath, which extended throughout the whole series of the laminæ, and of which portions are frequently found adhering to the inner edges of the ventral margins and the lateral fragments of the laminæ. This sheath corresponds with the siphon of the Belemnites, and is represented in the Sepion by the calcareous layer which, extending over the posterior edges of the laminæ, covers the entire surface of the last lamina, and it presents, as M. Voltz states, an intermediate form between the narrow, straight siphon of the Belemnites and the wide, open cavity of the Sepion.

Whether the spaces between the laminæ were filled with minute columnar partitions, similar to those which characterise the Sepion, or whether they were simple air-chambers, we have not at present any evidence to determine. The probability is, that they were simply air-chambers; for no trace whatever of any substance similar to that termed the spongioid tissue of the Sepion has been found, which, had any such substance existed, might reasonably have been expected; and the true siphonal structure, to which the Belosepion presents so close an approximation, is always associated with simple air-chambers. The Belosepion, as its rostrum indicates, belonged to a Cephalopod eminently littoral in its habits, and the size, notwithstanding the extraordinary development of the rostrum, leads us to believe that the animal was not only smaller, but a less powerful swimmer, than the recent Sepia. We should expect, therefore, to find in it some provision for buoyancy beyond that with which the recent Sepia is furnished, not only for the purpose of increasing the swimming power of the animal, but also as a compensation for the large and dense rostrum and callus which characterise its remains. But if the interlaminar spaces were filled with any substance resembling the spongioid tissue of the Sepion, the floating apparatus of the Belosepion would be apparently inadequate to the wants of the animal. The form and mode of superposition of the laminæ, somewhat resembling the arrangement of the septa in *Spirulirostra*, present a closer analogy with the phragmocone of the Belemnites than with the plates of the Sepion. These considerations give additional weight to the opinion of M. Voltz, founded on the appearance of what he terms the "alveolar sutures," that the Belosepion was a camerated and siphoniferous shell.

The rostrum of the Belosepion presents a structure analogous with that of the

spathose guard of the Belemnite. It has a tendency to split in two along the centre, in a vertical plane, from the ventral to the dorsal aspect; and it is composed of successive conical layers, each enveloping the preceding layer, and exhibiting a fibrous texture crosswise. The anterior lateral and dorsal portions present straight plates, longitudinally fibrous, resembling the structure of the *Belopteru Belemnitoidea*, and the external edges hang over each other, and give an imbricated appearance to that part of the rostrum.

In order to appreciate the differences which appear to render it desirable that the genus *Belosepia* should be retained, it may be well to give a short description of the internal shell of the recent *Sepia officinalis*. This will be found to consist of five distinct parts: 1st, an outer layer of calcareous matter, called the *buckler* or sheath, convex, rugose externally, and prolonged at the posterior extremity into a calcareous spine, placed in the medial line, and inflected towards the ventral aspect; 2d, a series of horny layers imposed one over another, extending over the posterior dorsal surface of the buckler, and wholly enveloping and extending beyond the spine; 3d, a thin horny layer spread over the whole of the internal surface, and extending beyond the edges of the buckler, and which, in its turn, is entirely covered by, 4th, a calcareous layer, which contains the spongioid tissue and, 5th, a series of convex horny laminæ, impregnated with carbonate of lime, placed horizontally, the posterior edge of each succeeding lamina being a little withdrawn from that of the preceding lamina, so that by this mode of superposition they present a depression or cavity immediately above the origin of the spine, and gradually rise into a convex mass at the middle and upper extremity of the shell. The spaces between the laminæ act as air-chambers, but there is not any siphuncle or siphonal opening; and the surfaces of the laminæ are studded with an infinite number of minute columnar and sinuous partitions, placed at right angles to the laminæ, and giving them support.

It will be seen from this that the Belosepion, although bearing a close general resemblance to the Sepion, still presents several strongly-defined differences. The elevated calcareous mass or callus, which, in the Belosepion, terminates the sheath on the dorsal aspect, attaining frequently a considerable size, is not found in the Sepion: and the fold, which in the latter is represented by a series of horny layers, distinct from, but wholly enveloping, the spine, is, in the former, a thick calcareous plate, formed by the expansion and retroflection of the anterior extremity of the rostrum, and extending barely beyond the line of the callus. In the Sepion the rostrum is small, in some species little more than rudimentary, and inflected, if at all, towards the ventral aspect. In the Belosepion, on the contrary, it attains a very large size, and, as M. Pictet observes, would indicate a gigantic animal if it were in relation to the animal in the same proportion as the Sepion; and it is invariably inflected towards the dorsal aspect. The internal laminæ of the Sepion are horizontal, equidistant, and parallel, and so arranged as to form a hollow at the posterior ventral portion of the sheath, but rising

into an elevated mass towards the middle; while in Belosepion, after emerging from the terminal cavity, in which they radiate, as it were, from the origin of the fold, they are at first nearly vertical, with the edges of the ventral margins ranged in a line with the ventral surface of the rostrum, and converging towards the inverted apex of the sheath; so that, as the sheath enlarges, the dorsal edges of the laminæ become more and more distant, and the laminæ themselves tend gradually towards a horizontal position; and in fact, in an adult individual, the last laminæ become nearly horizontal.

Owing to the different mode of arrangement of the laminæ, the *Sepion* and *Belosepion* differ materially in their shape and general aspect. In each the dorsal plate or sheath is extended so as to embrace the laminæ; but in the *Sepion*, the laminæ of which are horizontal, and placed in a direction nearly parallel with the sheath, it is necessarily much less convex and more extended than in the *Belosepion*, in which the laminæ, being vertical, or more or less vertically inclined, present to it merely their dorsal and lateral margins. The buckler of the *Sepion*, and its contents, are, therefore, in form an elongated oval, depressed in the direction from the ventral to the dorsal aspect, and but slightly convex on the surfaces; while in the *Belosepion* the sheath is considerably shorter, enlarging gradually towards the anterior extremity, and presents a deep semiconical cavity, containing within it the whole area of the laminæ, and it is obliquely truncated at the anterior extremity, and flat on the ventral surface, which does not extend to half the length of the shell. The most important difference, however, is, that the laminæ of the Belosepion possess large ventral, siphonal, or siphoniform openings, a structure which is not found nor represented in the Sepion.

These distinctions indicate corresponding zoological peculiarities; and the animal, although, perhaps, resembling Sepia more closely than any other recent Cephalopod, must yet have presented such marked differences from it as to render it impossible satisfactorily to refer its remains to that genus, and fully to justify the separation proposed by M. Voltz. I have, therefore, retained that author's genus, *Belosepia*, notwithstanding the array of authorities against it; and I have the less hesitation in doing this, when I find that Cuvier did not refer the remains in question to *Sepia*, but to some Cephalopod closely allied to that genus; and that M. de Blainville, when he adopted the genus *Beloptera*, did not hesitate to remove them from the genus Sepia, to which he had referred them, although he placed them, under some misapprehension, in the genus *Beloptera*.

With respect to the place of Belosepia in the systematic arrangement, as the shell presents a camerated and siphoniform structure and a terminal guard, and is therefore more nearly related to Belemnite than the recent Sepia, I have removed it from the family *Sepidæ*, in which M. d'Orbigny has placed it, to the family Belemnitidæ. It seems to have prepared the way for the recent Sepia, and leads from that genus, by a natural and easy transition through Beloptera and Belemnosis, into Belemnitella and Belemnite.

The specific characters are taken from the rostrum, the callus, and the fold. These parts, however, are of secondary importance only, and would vary in form considerably, not only with the age, but probably with the sex of the animal. Distinctions founded upon them, therefore, must necessarily be somewhat vague and uncertain; and, in fact, M. Deshayes, from not attaching sufficient importance to changes resulting from age or other circumstances, has proposed three distinct species, viz. *Belosepia longispina*, *B. longirostris*, and *B. Blainvillii*, on remains which, as well as those of the *B. Cuvieri* (of Deshayes), M. d'Orbigny considers to be varieties of the same species attributable to age.

Four well-defined species are known at present, viz. 1st, B. sepioidea (De Blainv.), consisting of S. longispina, S. longirostris, and S. Blainvillii (Desh.); 2d, B. compressa (De Blainv.); 3d, B. Cuvieri (Desh.), which I consider to be the B. Owenii of Sowerby; and 4th, B. brevispina (Sowerby). With the exception of the B. compressa, which has not yet been found in England, they all occur in the eocene strata of this country. The first three species are found in the Paris basin, and the B. Cuvieri has also been found in the tertiary deposits of Belgium.

No. 1. BELOSEPIA SEPIOIDEA. *De Blainv.* Tab. I, fig. 1 *a—i.*

BELOPTERA SEPIOIDEA; *De Blainv.* 1825. Mal. add. et correct. p. 621, tab. 11, fig. 7.
SEPIA CUVIERI; *D'Orb.* 1825. Tab. Méth. de la Classe Ceph. p. 67.
BELOPTERA SEPIOIDEA; *De Blainv.* 1827. Mém. sur les Bélem. p. 110, tab. 1, fig. 2, 2*a*, 2*b*.
— — *Sowerby.* 1829. Min. Con. vol. vi, p. 183, tab. 591, fig. 1.
BELOSEPIA CUVIERI; *Voltz.* 1830. Obs. sur les Bélem. p. 22, tab. 2, fig. 6*a—g*.
SEPIA CUVIERI; *Galeotti.* 1837. Mém. sur la Constit. Géogn. de la Prov. de Brabant, p. 140.
— LONGISPINA; *Desh.* 1837. Foss. des Env. de Paris, p. 757, tab. 101, fig. 4-6.
— LONGIROSTRIS; „ „ p. 758, tab. 101, fig. 10-12.
— BLAINVILII; „ „ „ „ fig. 13-15.
— CUVIERI; *Bronn.* 1837. Lethæa Geognostica, p. 1127, tab. 42, fig. 19 *a—c*.
BELOPTERA LONGIROSTRUM; *Morris.* 1843. Cat. of Brit. Foss. p. 178.
SEPIA LONGIROSTRIS; *Pictet.* 1845. Traité élém. de Paléont. vol. ii, p. 315.
— LONGISPINA; „ „ „ „
— BLAINVILLII; „ „ „ „
— SEPIOIDEA; *D'Orb.* 1845-7. Moll. viv. et fos. vol. i, p. 269.
BELOSEPIA CUVIERI; *J. D. C. Sowerby.* 1849. Dixon's Geol. Hist. of Bracklesham, Selsey, and Bognor, &c., p. 109, tab. 9, fig. 11*a*.
— LONGIROSTRIS; „ „ p. 109, tab. 9, fig. 15.
— LONGISPINA; „ „ p. 109, tab. 9, fig. 12.
— BLAINVILLII; „ „ p. 109, tab. 9, figs. 16, 17.
Non SEPIA CUVIERI; *Desh.* Foss. des Env. de Paris, p. 758, tab. 101, figs. 7-9.

B. rostro elongato, crasso, acuto, recto aut plus minusve arcuato; laminâ ventrali crassâ, profundè radiatim sulcatâ, in margine posteriori denticulatâ; callo dorsali profundè et irregulariter rugoso, deorsum producto aut erecto.

This species presents considerable variations in the form, as well of the callus as of the rostrum; and, in fact, M. Deshayes has separated it into the three species *B. longispina*, *B. longirostris*, and *B. Blainvillii*, chiefly on account of the different conditions of the rostrum. M. d'Orbigny, attributing the variableness of the rostrum to the age of the animal, or to alterations caused by fossilization, to which I would also add changes resulting from attrition, has united these species under the specific name *B. sepioidea*, originally given by De Blainville. Possessing a long series of specimens, comprising individuals in different stages of growth, and in which the peculiarities of form, taken by M. Deshayes as specific characters, appear to pass gradually into each other, I have no doubt as to the propriety of the union, proposed by M. d'Orbigny, of the three species above mentioned. That author, however, has added to them a fourth species, proposed by M. Deshayes, *B. Cuvieri;* but which, as it exhibits constant and well-defined differences, I think should be retained.

The *rostrum* of *B. sepioidea* is elongated, and pointed at its posterior extremity; on the inferior or ventral surface it is sometimes, particularly when young, nearly straight, but more frequently it is bent, at about half the length, in an angle more or less obtuse, towards the dorsal aspect; the dorsal surface presents a sharp cutting edge, slightly arched, and, at its juncture with the callus, exhibits a depression, which is strongly marked in mature specimens. At the base, immediately beneath the callus, it is more or less dilated, and it is angulated at the margins; the ventral surface is more or less convex. The *callus* is narrow, compressed, and deeply rugose; the posterior margin forms an acute angle with the axis of the rostrum, varying considerably in different specimens. In some instances the inclination of the posterior margin is at an angle more or less obtuse with the axis of the rostrum; a condition which, as it appears to me, is attributable to the fracture and attrition of the extremity of the callus, as the specimens in which this form occurs present a smooth worn appearance. The *ventral plate*, immediately beneath the rostrum, is nearly horizontal, but presents a broad undulation, corresponding with the convexity of the ventral surface of the rostrum; the lateral extremities, as they approach the sheath, gradually diminish in breadth, and assume a nearly vertical position. In consequence of this variation in breadth, the ventral plate, which, at the superior margin, is nearly semicircular, presents a regular semielliptical form on the posterior margin. It exhibits on the ventral surface a series of sulci, radiating from the apex of the terminal cavity, and varying in depth; and it is deeply and sharply denticulated on the posterior margin. As the shell enlarges, the plate is thickened considerably by successive layers added to the ventral surface. The last layers frequently do not envelope, but are a little withdrawn from the margin of, the preceding layers, leaving the previous denticulations partly uncovered; and consequently the margin of the ventral plate, in an adult specimen, often presents a double row of denticulations.

The lateral portions of the sheath exhibit deep vascular impressions at the posterior extremity.

The *B. sepioidea* is found plentifully at Bracklesham Bay, on the coast of Sussex; it is also found at Stubbington (near Gosport) and at Sheppy. In France it occurs, according to M. d'Orbigny, in the lower calcaire grossier at Chaumont (en bas), Vivray, and Saint Germain; in the upper calcaire grossier at Chaumont (en haut), Grignon, Courtagnon, Parnes, Muchi-le-Châtel, &c., and, in the sandy beds above the calcaires grossiers, at Tancrou, Aumont, Acy, &c.

The specimen (Pl. 1, fig. 1*h*) exhibits nearly the entire form of the shell; it was found at Sheppy, and enriches the cabinet of Mr. Dixon. The length is four inches, and the breadth across the superior extremity of the sheath, if the cast were perfect, would be rather more than an inch. The remains commonly found seldom consist of more than the rostrum, with, occasionally, portions of the ventral plate, and, more rarely, of the posterior extremity of the sheath. The ordinary size of the rostrum is six tenths of an inch* long, and three tenths wide at the superior extremity.

No. 2. BELOSEPIA CUVIERI. *Deshayes.* Tab. I, fig. 3 *a—e.*

SEPIA CUVIERI; *Desh.* 1837. Foss. des Env. de Paris, p. 758, tab. 101, fig. 7-9.
— — *Nyst.* 1843. Descr. des Coq. et des Polyp. des Terr. tert. de la Belg. p. 610, tab. 46, fig. 1.
— — *Pictet.* 1845. Traité élém. de Paléont. vol. ii, p. 315.
— SEPIOIDEA (sp.); *D'Orb.* 1845-7. Moll. viv. et fos. vol. i, p. 269.
BELOSEPIA OWENI; *J. D. C. Sowerby.* 1849. Dixon's Geol. Hist. &c. p. 109, tab. 9, fig. 13*a*.
Nec SEPIA CUVIERI; *D'Orb.* 1825. Tab. Méth. de la Classe Ceph. p. 67.
Nec BELOSEPIA CUVIERI; *Voltz.* 1830. Obs. sur les Bélemn. p. 22, tab. 2, fig. 6*a-g*.
Nec SEPIA CUVIERI; *Sow.* Min. Con. vol. vi, p. 183, tab. 591, fig. 1.
Nec BELOSEPIA CUVIERI; *J. D. C. Sow.* 1849. Dixon's Geol. Hist. &c. p. 109, tab. 9, fig. 11*a*.

B. Testâ extremitate posticali lateraliter dilatatâ; rostro brevi, crasso, arcuato, acuto, ad basim latissimo; laminâ ventrali arcuatâ, profundè sulcatâ, in margine denticulatâ; callo dorsali profundè rugoso, margine inferiori recto aut sursum vergenti.

M. Deshayes, in his description of this species, refers to Beloptera sepioidea (Beloptère de Cuvier) of De Blainville, and to the specimen figured by Mr. Sowerby in 'Mineral Conchology,' as identical with it. The description given by M. de Blainville is rather sub-generic than specific, and is too general for the purpose of identity; but the figures given by him are evidently those of a mutilated specimen of

* In stating the size of the shells I have used tenth parts of an inch, in order to facilitate a comparison with the measurements of French shells; as tenths of an inch may be readily, and with sufficient accuracy, converted into "millimetres" by taking 1 tenth as equal to $2\frac{1}{2}$ millim. The exact proportion is 305 millim. = 12 inches; i. e. ·1 in. = 2·54166 &c. millim.

B. sepioidea, and do not correspond with the specific description given by M. Deshayes. Through the kindness of Mr. Sowerby I have had an opportunity of examining the specimen from which his figure was taken, and it is unquestionably a B. sepioidea; the peculiar form of the rostrum being caused by the fracture of the posterior extremity, and the abrasion of the lower part of the outer layers. The present species is well defined by M. Deshayes; and as I have a series of specimens in different stages of growth in which the distinctions are preserved, I do not hesitate to retain it.

The *rostrum* is short, thick, slightly arched, and very broad at the superior extremity; on the dorsal surface, at the posterior extremity, it is compressed, and presents a cutting edge for about one half of the length; the superior extremity is marked by a broad depression extending to the callus. The *ventral plate* is less elliptical, and the denticulations less prominent, than in *B. sepioidea*. The *callus* is nearly perpendicular to the axis of the rostrum, and enlarges rapidly, owing to the greater width of the terminal cavity.

The specimen figured in Mr. Dixon's work, under the name *B. Owenii*, appears to belong to this species. Mr. Sowerby was probably induced, by the synonyms quoted by M. Deshayes, to consider the *Sepia Cuvieri* of that author as identical with the *Beloptère de Cuvier* of De Blainville; and as the specimen before him could not be referred to that species, he proposed the species *B. Owenii* for its reception. The specific name *Cuvieri*, however, having been improperly used by MM. d'Orbigny and Voltz for the *B. sepioidea* of De Blainville, must now be retained for the present species, to which it was applied by M. Deshayes, and it will consequently supersede the name *Owenii* proposed by Mr. Sowerby. M. Nyst cites for his specimens M. Deshayes's description of *B. Cuvieri*, and has, in fact, copied the figures given by that author. I have therefore considered them as identical.

Hitherto, I believe, B. Cuvieri has been found, in England, only at Bracklesham Bay, where it is not by any means common. The French localities quoted by M. Deshayes are Grignon, Courtagnon, Parnes (upper cal. gross.). M. Nyst gives the sandy beds at Boitsfort, Assche, Jette, Forêt, Uccle, and Ghent, as the Belgian localities.

The length of the rostrum is ·3 inch, and its breadth at the superior extremity ·3 inch.

No. 3. BELOSEPIA BREVISPINA. *Sowerby.* Tab. 1, fig. 2 *a—c.*

BELOSEPIA BREVISPINA; *J. D. C. Sowerby.* 1849. Dixon's Geol. Hist., &c., p. 109, tab. 9, fig. 14.

B. rostro per-brevi, crasso, acuto, in aspectum ventralem valde convexo et regulariter arcuato; laminâ ventrali profundè sulcatâ, vix denticulatâ; callo dorsali in margine inferiori compresso, sursum vergenti.

A species much resembling the young of *B. Cuvieri;* but, according to the few specimens we possess at present, it is distinguishable by the shortness and the greater convexity of the inferior surface of the rostrum, and also by the dorsal surface, which is rounder than in *B. Cuvieri*, slants downwards, and, even in the largest specimens, barely presents the cutting edge which distinguishes the two preceding species. The *callus* is longer in proportion, and is so much compressed, as to present a narrow, almost a sharp edge; and it enlarges more rapidly than even in the last species, owing to the greater width of the terminal cavity.

The *ventral plate* is semicircular, and nearly smooth on the inferior margin, and, owing to the width of the cavity, is transversely elliptical on the superior margin; it is also narrower and more deeply sulcated than in *B. Cuvieri.*

The *B. brevispina* is found at Bracklesham Bay, and is very rare. I possess four specimens of different sizes, which all present the same characteristic form; but it is not improbable that a larger series would show that the species is but the young form, or at all events only a variety, of *B. Cuvieri.*

The length of the rostrum is ·2 inch; the width rather less than ·2 inch.

Genus 2d. Belopteba. *Deshayes.**

Animal unknown, but supposed to have been closely allied to the Belemnite, which, as described by Professor Owen, appears to have been oblong; the head, surrounded by ten arms, (?)† furnished, like those of the recent genus *Onychoteuthis*, with a double alternate series of slender, elongated, horny hooks; mandibles horny; (?) the body purse-shaped, conical, elongated, supporting near the middle two lateral fins, rounded and entire along their free margin; inclosing an ink-bag.

Shell internal, composed of two cones placed apex to apex, united, and expanding on each side into wing-shaped appendages, obliquely inclined towards the ventral aspect; the anterior cone smooth, longitudinally fibrous, hollowed into a deep conical cavity, containing regular transverse concave septa, pierced by a ventral siphon.

B. Testâ internâ, duobus conis, apice ad apicem conjunctis, formatâ; utroque latere duobus appendicibus aliformis, deorsum inclinatis, sustentâ; superficie dorsali convexâ, ventrali concavâ; cono anteriori lævigato, longitudinaliter fibroso, cavitati conicâ, profunda, septa transversa continenti, excavato; septis concavis, regularibus, siphone ventrali perforatis.

Guettard, the first author by whom these remains appear to have been noticed,

* Etym. Βελος, telum; πτερον, ala.

† The eight *sessile* or normal arms only have as yet been found preserved. Professor Owen states that the traces of the superadded pair of tentacula are somewhat doubtful.

described them as the teeth of fish. Long subsequently, M. Deshayes examined similar remains found in the Paris basin; and, having observed in them characters which induced him to refer them to an extinct Cephalopod nearly allied to the Belemnites, he proposed the present genus for their reception. M. de Blainville, whose 'Manuel de la Malacologie' was then in course of publication, and to whom M. Deshayes had communicated his proposed genus, confounded with the remains in question those of the so-called fossil Sepiæ (Belosepiæ); but in adopting the genus *Beloptera*, he divided it into two sections, the first containing the fossil Sepiæ, which he characterised as species having wing-shaped appendages united at the superior extremity of the rostrum; the second section containing the true Belopteræ, he described as species having the appendages distinct and the cavity conical, and with chambers and a siphuncle. The mistake is continued by M. de Blainville, in the Supplement to his 'Mémoire sur les Bélemnites,' published in 1827. In 1830, Voltz pointed out the differences which rendered it necessary to keep the two genera distinct; and, about the same time, M. Deshayes published, in the 'Encyclopédie Méthodique,' under the article Béloptère, the grounds which induced him to establish that genus. Notwithstanding this publication, however, the error into which M. de Blainville had fallen was repeated by MM. d'Orbigny and de Férussac, in their 'Histoire des Céphalopodes,' and by Cuvier, in his Memoir on the bones of the fossil Cuttle-fish, published in the 'Annales des Sciences Naturelles.'

Mr. Sowerby afterwards, when he adopted the genus provisionally for the curious and unique fossil obtained from Highgate, which he published in the 'Mineral Conchology' under the name *Beloptera anomala*, confined the genus to those species which contained a chambered cone like the Belemnites, and referred the species contained in M. de Blainville's first section to the genus *Sepia*. The absence, in the Highgate fossil, of the lateral wing-shaped expansions, and of the blunt terminal rostrum which characterise the two known species of *Beloptera*, as well as other characters to which I shall hereafter refer, seems to me to require the establishment of a distinct genus for the reception of those remains; and the genus *Beloptera* will be then confined to those species which possess lateral expansions, and which, as M. Deshayes himself describes them, exhibit an entire conical and chambered cavity, resembling that of the Belemnite, joined to a terminal rostrum, like that of the Belosepia.

As thus restricted, the *Belopteræ* present, at the anterior extremity, a semiconical cavity, slightly depressed on the ventral aspect, in which was contained a thin calcareous layer, covering the entire inner surface. The inner cone formed by this layer contained a series of transverse, regular, and exceedingly thin septa, traces of which, consisting of their sutures or lines of junction with the inner sheath, are very distinct. These sutures, as they approach the ventral aspect, are slightly bent downwards towards the inverted apex of the cone, and present an acute sinus-like inflection

as they rise over a slight linear elevation, which traverses the whole length of the alveolus, along the medial line of the ventral inner surface, evidencing the presence and position of the siphuncle. The opening, or anterior extremity of the conical cavity, is slightly elliptical, having the shorter axis in the direction from the ventral to the dorsal aspect. The margin of the outer sheath is thin and sharp, and its ventral paries is much thicker than the dorsal paries, and rises into an elevated mass, depressed on the surface. The outer sheath itself is composed of a series of concentric layers, and exhibits a fibrous texture, like the sheath of the Belemnite. The apex is prolonged into a dense calcareous mass, strongly inflected towards the ventral aspect, and enlarged towards the posterior extremity, where it becomes attenuated, and is obliquely truncated. This mass is composed of longitudinal laminæ, radiating from the apex of the cone, and so arranged, that the central laminæ are in a plane extending from the ventral surface to the back, and the rest in planes gradually diverging more and more towards the back. The outer edges of the laminæ are distinct and slightly elevated, giving a rough sulcated appearance to the surface. The cone and the calcareous mass into which it is prolonged expand laterally into two smooth semi-elliptical appendages, inclined obliquely towards the ventral aspect, thin and sharp on the outer edges, and gradually thickening as they approach their bases. These expansions consist of two distinct series of layers, deposited on the ventral and dorsal surfaces, and exhibit impressions which, as M. Deshayes remarks, are probably attributable to the presence of a vascular system in the substance of the mantle.

It will be seen from the foregoing description that *Beloptera* presents a much closer analogy with the Belemnites than that exhibited by *Belosepia*. The open semiconical cavity of the latter, in its typical form, nearly resembles the sheath of the Sepion; but the laminæ, both in their mode of arrangement and in their large siphoniform openings, present the first indications towards the phragmocone of the Belemnite. In the aberrant form, *Belosepia compressa*, both the sheath and the laminæ recede a step further from the Sepion type, and prepare the way for, and in fact connect *Belosepia* with, *Beloptera*. In this genus a still nearer approach to Belemnite appears; the wide, open, but shallow sheath of the Sepion, with its siphonless and nearly parallel laminæ, is lost, and is replaced by an entire conical sheath, containing regular transverse septa perforated by a siphuncle, and exactly corresponding with the sheath and phragmocone of the Belemnite. The fold of the Belosepion, formed by the retroflexion and lateral enlargement of the ventral paries of the sheath, largely developed in the typical form, disappears in *Beloptera*, and is represented by the lateral expansions which characterise that genus, and which, greatly reduced in size in *Beloptera Levesquei*, lead directly into the simple sheath of the Belemnite; while the strongly inflected rostrum of the Belosepion assumes the form of a somewhat conical mass, and thus prepares the way for the elongated and regularly conical guard of Belemnite.

Exclusive of the Beloptera anomala (Sow.), for which I have proposed the genus *Belemnosis*, only two species of Beloptera are as yet known, i. e. *B. Belemnitoidea*, and *B. Levesquei*. Both species occur in the Paris basin, and in the Eocene beds of England. The first has also been found at Laeken in Belgium, and at Biaritz.

The specific characters are taken from the conditions of the lateral expansions and of the conical sheath.

No. 4. BELOPTERA BELEMNITOIDEA. *De Blainville.* Tab. 2, fig. 1*a—g*.

TOOTH OF A FISH; (?) *Guettard.* 1783. Mém. sur les Glossopètres, tab. 2, figs. 10, 11, 12.
BELOPTERA BELEMNITOIDEA; *De Blainv.* 1825. Mal. add. et correct. p. 621, tab. 11, fig. 8.
SEPIA PARISIENSIS; *Fér. et D'Orb.* 1825. Tab. Méthod. des Céph., Ann. des Sc. Nat. vol. vii.
BELOPTERA BELEMNITOIDEA; *De Blainv.* 1827. Mém. sur les Bélemn. p. 111, tab. 1, figs. 3, 3*a*, 3*b*.
— — *J. D. C. Sowerby.* 1829. Min. Con. vol. vi, p. 183, tab. 591, fig. 3.
BELOPTERA BELEMNOIDEA; *Voltz.* 1830. Obs. sur les Bélemn. p. 20.
BELOPTERA BELEMNITOIDEA; *Deshayes.* 1830. Encyc. Méthod. vol. ii, p. 135.
— — *Keferstein.* 1834. Die Naturgeschichte der Erdkörpers, &c. p. 430, No. 2.
— — *Deshayes.* 1837, Descrip. des Foss. des Env. de Paris, p. 761, tab. 100, figs. 4-6.
— — *Bronn.* 1837. Lethæa Geog. p. 1129, tab. 42, fig. 18*a-b*.
— — *Fér. et D'Orb.* 1839. Céph. Acetab. Seiches, tab. 3, figs. 7-9; tab. 24, figs. 11-12.
— — *Nyst.* 1843. Descr. des Coq. et des Polyp. foss. &c. p. 612, tab. 6, fig. 2.
— — *Pictet.* 1845. Traité élément. de Paléont. vol. ii, p. 316; tab. 14, fig. 2.
— — *Deshayes.* 1845-6. 2d Edit. de l'Histoire Nat. &c. p. 243.
— — *D'Orb.* 1845-7. Moll. viv. et foss. vol. i, p. 308, tab. 14, figs. 1-4.
— — *J. D. C. Sowerby.* 1849. Dixon's Geol. Hist. of Bracklesham, &c. p. 109, tab. 9, fig. 18.

B. testâ ovato-elongatâ, longitudinaliter recurvâ; supra convexâ; subtus concavâ, depressâ; cavitate anticâ sub-cylindricâ: rostro obtuso, striato: appendicibus lateralibus magnis, semicircularibus.

Shell oblong, compressed; the sheath straight and nearly elliptical; the ventral paries considerably thickened and depressed on the medial line below the siphuncle, so as to present an elevated sub-quadrate ridge, bifurcated at the posterior extremity. The rostrum enlarges gradually for about two thirds of the length, and then diminishes towards the extremity, which, in young specimens, is nearly conical in form, but in adult ones becomes very obtuse, probably from attrition; it is inflected towards the ventral aspect whence the shell presents longitudinally a somewhat arched appearance. The

lateral expansions are inclined towards the ventral aspect, and give a convex form to the dorsal surface, and a corresponding concavity to the ventral surface; they are thick at the juncture of the rostrum and sheath, and become gradually thinner as they enlarge, presenting a sharp cutting edge on their free outward margins. In this, the typical species, they are largely developed, regular in form, and vary considerably in size according to the age of the individual; in young specimens they present an elongated semielliptical form, which, as the shell advances towards maturity, becomes nearly semicircular.

Figs. 1*f* and 1*g* represent a variety in which the inferior cone is shorter, broader, and more compressed, and the wings are wider than in the ordinary specimens.

The *B. Belemnitoidea* is found in England at Bracklesham Bay, where it is somewhat rare. In France it is found in the nummulitic bed at Biaritz, in the Lower Pyrenees; the lower beds of the calcaire grossier at Vivrais, Grypseuil, and Pouchon (Oise), and, in the middle beds, at Grignon, Parnes, Muchi-le-Châtel, Chaumont, &c. It also occurs in Belgium, in the sandy beds at Laeken.

The size is eleven lines in length, and four lines and a half in width across the widest part of the lateral expansions.

No. 5. Belopтera Levesquei. *D'Orbigny.* Tab. 2, fig. 2*a*—*e*.

Belopтera Levesquei; *D'Orb. et Fér.* 1839. Céphal. Acetab. Seiches, tab. 20, figs. 10-12.
— — *Pictet.* 1845. Traité élément. de Paléont. vol. ii, p. 316.

B. testâ oblongo-elongatâ, arcuatâ, subtus carinatâ, lateribus depressâ, sub-excavatâ; anticè cylindrico-angustatâ: rostro obtuso, striato: appendicibus lateralibus parvis, linearibus.

Shell elongated, arched: the sheath straight and nearly cylindrical; the ventral paries thickened, and laterally much compressed, so that, instead of the flat square-shaped, bifurcating ridge which distinguishes the preceding species, it presents along the middle of the sheath, beneath the siphuncular line, a somewhat acute angular keel, which is continued on the upper part of the rostrum, and the sides of which are a little depressed. The rostrum itself is larger, and is transversely more compressed, and less inflected towards the ventral aspect, than that of *B. Belemnitoidea.*

M. d'Orbigny describes the species as destitute of lateral expansions; but, in the figures given by him, there are unquestionable indications of those appendages, very slightly developed it is true, yet still representing the wing-shaped expansions which characterise the genus. In one of the two English specimens, the only two with which I am acquainted, and for the use of which I am indebted to Mr. Wetherell, the lateral expansions are broken away, but their existence is evidenced by a deep suture on each side where they were inserted into the shell. The other specimen unfortunately is broken off just above the juncture of the sheath with the rostrum, at the precise part

at which the expansions would first appear; but their presence is indicated by a slight curve in the outline caused by their origin. I do not hesitate, therefore, to attribute to this species the characteristic lateral enlargements, although they are very feebly developed.

M. Deshayes, in his 'Description des Coquilles fossiles des Environs de Paris,' mentions a specimen in his possession, too much mutilated for description, in which the rostrum is smoother and more elongated, and the wings appear to be much narrower than in B. Belemnitoidea, and not to be inclined downwards as in that species; and for which, when better known, he thinks it will be necessary to form a new species. May not that specimen be referred to this species, which has been established since the publication of M. Deshayes's work?

The English specimens of this species have hitherto been found only at Highgate, and are exceedingly rare. In France, according to M. d'Orbigny, the species occurs only in the lower strata of the Paris basin; that is to say, in the sands below the nummulite bed, at Thury-sous-Clermont, Gilocourt, and Cuise-Lamotte (Oise).

The size is twelve lines long and three lines wide.

Genus 3d. Belemnosis.* *F. E. Edwards.*

Beloptera; *J. D. C. Sowerby.*

Animal unknown but supposed to be closely allied to the Belemnite.

Shell internal, oblong, semiconical, with the apex inflected towards the ventral aspect, and enlarged into an obtuse umbo, pierced by a pore on the ventral surface; the anterior part hollowed into a deep semiconical cavity extending to the pore, and having the inner surface covered by two calcareous sheaths, one within the other, continued over the ventral surfaces of, and enveloping, a series of transverse septa, perforated by a ventral siphon.

Testâ interná, oblongâ, semiconicâ, apice deorsum inflecto et in umbonem obtusum, foramine perforatum, dilatato; parte anteriori in cavitatem semiconicam, profundam, ad foramen tendentem, et septa transversa, siphone ventrali perforata, continentem, excavatâ; cavitatis superficie duobus laminis conicis, pertenuibus, circa septa productis et ea involventibus, obtectâ.

The remarkable remains for the reception of which I propose the present genus are described by Mr. J. Sowerby in the 'Mineral Conchology,' and are referred by that author to *Beloptera*. M. Deshayes, in the first instance, in the 'Description des Coquilles fossiles, &c.,' expressed an opinion that they could not be placed in that genus; subsequently, however, in the notice of the genus Beloptera, introduced in the second edition of Lamarck, after speaking of *Belop. Levesquei*, he refers not only that

* Etym. Βελεμνον, telum; ενωσις, conjunctio.

species but also the *Beloptera anomala* of Sowerby to the genus Beloptera, the principal character of which he states to be the association of a conical chambered cavity, similar to that of the Belemnites, with the beak (rostrum) of the Sepia. M. d'Orbigny also (Moll. viv. et foss.) refers to that genus the remains in question, which, he says, resemble *Beloptera Levesquei* in the absence of the lateral wings, but are distinguished from it as well by the want of the under part (the ventral paries) of the shell and of a distinct beak, as by the air-chambers being apparent on the under side. These remains unquestionably bear a close affinity to Beloptera; but the peculiarities they present appear to me to separate them distinctly from that genus, and fully to justify the establishment of a new genus for their reception.

The shell of *Belemnosis* consists of an elongated semiconical sheath, the apex of which expands into a short semicylindrical umbo, pierced on the ventral surface, and inflected towards the ventral aspect. The sheath is convex on the dorsal surface, and is without a ventral paries; the margins at the superior extremity are narrow, and present outwardly sharp edges, which extend rather more than one third of the length of the shell; as the margins approach the inferior extremity they expand, and the inner edges gradually become nearer to each other, until they unite immediately above the umbonal pore. The margins of the pore are elevated, and the pore itself penetrates to, and communicates with, the air-chambers. The septa are transverse and concave; the presence of a siphuncle and its ventral position are indicated by angular inflections on the sutural impressions along the medial line of the ventral surface; the septa are contained in, and wholly enveloped by, a thin conical sheath, which also is covered by a second and somewhat thicker conical layer lodged in the outer sheath.

The principal character of *Beloptera*, viz., the association of the elongated rostrum of the Sepion with the phragmocone of the Belemnite, fails in *Belemnosis;* and the lateral expansions which, assuming their fullest development in *Beloptera Belemnitoidea*, still characterise *B. Levesquei*, although reduced in that species to prominent carinæ, are here wanting, or, at the utmost, are but feebly represented by the sharp outer edges of the ventral margins of the sheath. In *Beloptera*, the outer cone, which contains the inner sheath and its contents, and which exactly corresponds with the phragmocone of the Belemnite, is entire; whereas, in *Belemnosis*, the ventral paries is wanting, or very thin. In this respect *Belemnosis* presents an analogy with *Belemnitella* (D'Orb.), a genus of the Belemnitidæ, characterised by a fissure in the phragmocone communicating with the external paries of the alveolus. This peculiar form of Belemnite at present appears to be confined to the upper chalk formation, and it would seem to connect the true Belemnite with the present genus, in which the fissure becomes largely expanded, resembling the wide cavity of Belosepia. Thus the transition from *Belosepia*, through *Belemnosis* and *Belemnitella*, into *Belemnite* will be easy and natural, and the chain of connexion between the latter genus and the recent *Sepia* will be complete.

The principal character, however, which distinguishes *Belemnosis* is the aperture forming a communication between the alveolar chambers and the sac in which the shell was lodged. In all the camerated siphoniferous shells, I believe without exception, the inferior extremity of the alveolus and phragmocone is perfectly closed, and the air-chambers have not any direct communication with the pallial sac; and, in fact, communicate only with the pericardial cavity by means of the membranous siphuncle. Walch, it is true, in his 'Recueil de Monumens, &c.,' figured a Belemnite, which he described as having a small circular hole at the extremity of a curved point; upon which figure, with embellishments of his own, De Montfort proposed the genus *Paclites*, referred to by Parkinson, and quoted by De Blainville. This genus, however, is universally rejected, as founded on characters merely accidental or imaginary. M. d'Orbigny states, that in certain exceptional cases the extremities of the rostra of Belemnites, at the last period of their growth, form tubular prolongations, and that they are also liable to distortion from accident. The extreme points of the successive layers, which form the spathose guard, are apparently, in some instances, more susceptible of disintegration than the other parts, and thus tubular openings may be formed along what Voltz terms the *apicial line*. But in all these cases the pore is merely terminal, and does not extend far up the sheath. The structure found in *Belemnosis*, therefore, appears to be peculiar to it; and would indicate an application of the siphuncular function, whatever that function may be, different from that in all other siphoniferous shells, and suggests a corresponding peculiarity in the organization of the animal.

From the absence of the elongated rostrum which characterises the *Belosepia* and *Belopteræ*, we infer that the animal of *Belemnosis* was not littoral in its habits, but existed in a comparatively deep sea; and the occurrence of the unique specimen, upon which the genus is founded, at Highgate, where the organic remains indicate a shallow-sea deposit, is attributable most probably to the casual drifting of the animal.

No. 6. BELEMNOSIS PLICATA. *F. E. Edwards.* Tab. 2, fig. 3*a*—*e*.

BELOPTERA ANOMALA; *Sowerby*. 1829. Min. Con. vol. vi, p. 183, tab. 591, fig. 2.
— — *Morris*. 1843. Cat. of Brit. Foss. p. 178.
— — *Pictet*. 1845. Traité élément. de Paléont. tom. ii, p. 316.
— — *Deshayes*. 1845-6. 2d Edit. de l'Hist. Naturelle, &c. par Lam.
— — *D'Orbigny*. 1845-7. Moll. viv. et foss. tom. i, p. 309, tab. 14, figs. 8-10.

B. testâ oblongo-elongatâ, supra convexâ, umbone obtusissimo, lateraliter compresso, et deorsum leviter inflecto terminatâ: marginibus ventralibus anticè depressis, posticè sub-convexis, facies externas acutas, internas, obliquè triplicatas, præbentibus: foramine umbonali circulari.

This shell is oblong, regularly convex on the upper surface, and terminated by a very obtuse, short umbo, compressed laterally, and slightly inflected towards the ventral aspect. The ventral margins are depressed, and present outwardly sharp edges, which extend rather more than one third of the length of the shell; the margins assume a convex form as they approach the inferior extremity, and at about two thirds of the length, become and continue nearly parallel until their union above the umbonal pore. The inner edges present three obscure, very oblique folds, from which character the specific name is taken. The umbonal pore is circular, and extends to the pyrites, with which the phragmocone is filled; it is about one fourth of the breadth of the shell in diameter. The septa are distant.

This unique and valuable specimen enriches the cabinet of Mr. Sowerby, whose kindness in conceding the use of it for description I beg to acknowledge. It was found in the clay removed in constructing the archway at Highway.

The length is ·5 in.; the breadth at the upper extremity is ·25 in., and across the umbonal pore ·15 in.

Order—*TETRABRANCHIATA. Owen.*

Family—Nautilidæ.

According to Von Buch, the division, which has been made of the tetrabranchiate Cephalopods into the two great families *Nautilidæ* and *Ammonitidæ*, has been determined solely by the position of the siphuncle, which, in the latter family, is invariably placed on the *ventral* margins of the septa; while, among the *Nautilidæ*, it is placed at or near the *centre* of the discs of the septa. Other differences exist in the form and condition of the septa, which, among the *Nautilidæ*, are characterised by simple curvatures or undulations, and by having their margins entire; while, among the *Ammonitidæ*, the septa present a series of lobes or sinuous flexures, the margins of which are foliated.

A third group, however, exists, in which the siphuncle is placed on the *dorsal* margin, and the septa are distinguished by angular or rounded lateral lobes, but their margins are perfectly simple. This group, for the typical forms of which Count Münster established the genus *Clymenia*, has been hitherto generally associated with the Nautilidæ; but I propose to separate it as a distinct family, under the name *Clymenidæ*.

The *Nautilidæ* will then be confined to those genera in which the siphuncle is *central* or *excentric*, that is, placed at the centre of the disc of the septum, or between that and the margin; or, more strictly, to those in which it is not placed either on the ventral or on the dorsal margin.

As thus restricted, the Nautilidæ will consist of the following genera: *Nautilus*,

Planulites, Lam., *Gyroceras*, *Lituitus*, *Campulites*, Desh. (Cyrtoceras, Gold.), *Phragmoceras*, *Orthoceras*, *Actinoceras*, *Koleoceras*, Portl., and *Poterioceras*, M'Coy (Gomphoceras, Sow.)

Of these genera, the Nautilus only has been found above the secondary formations.

The generic distinctions are taken chiefly from the position of the siphuncle, and the mode of convolution or the form of the shell.

Genus 4. NAUTILUS—*Gualtieri, Linnæus.*

OCEANUS; BISIPHITES. *De Mont.*
OMPHALIA. *De Haan.*

Gen. desc. Animal; *body* oblong, posteriorly rounded, and terminating in a slender membranaceous tube; *head* above, with an ambulatory disc; *arms*, nineteen (?) on each side;* *labial tentaculiferous appendages*, four, arranged round the mouth; *tentacula* of three kinds, viz. *ophthalmic*, lamellose, two on each side; *brachial*, annulose, twenty on each side; *labial*, annulose, twenty-four on each side; the whole body contained in the last chamber of a large multilocular shell, and affixed by two lateral muscles.

Shell; discoidal, spiral, multilocular, with simple walls; the whorls contiguous, the last covering the others; septa transverse, concave without, perforated in the disc, margins quite simple.

Animal corpore *oblongo, postice rotundato, tubo gracili membranaceo terminato;* capite *supra disco ambulatorio;* brachiis *utrinque novemdecem;* (?) appendicibus labialibus tentaculiferis, *quatuor, circum os dispositis;* tentaculis *trium generum, quorum*, ophthalmicis, *lamellosis, utrinque duobus;* brachialibus, *annulosis, utrinque viginti;* labialibus, *annulosis utrinque viginti quatuor; toto corpore in camerâ ultimâ testæ magnæ multilocularis recondito et musculis duobus lateralibus affixo.*

Testâ discoideâ, spirali, polythalamiâ, parietibus simplicibus; anfractibus contiguis, ultimo alios obtegente; septis transversis, extús concavis, disco perforatis, marginibus simplicibus.

The Nautilus is the only genus of the Cephalopoda which, appearing among the earliest forms of animal life, has survived the various changes which the earth has undergone. The large family, of which it forms the type, flourished during the Palæozoic epoch, and the Nautilus itself apparently attained its fullest development during the deposition of the carboniferous series, at which period nearly fifty species existed. Gradually diminishing in numbers, the genus passed through the Mesozoic epoch into the tertiary era, which it has also survived; and though reduced to four species, which have not any fossil representative,† it still exists in the tropical seas.

* M. Valenciennes states the number to be seventeen.

† The identification of the species in the Miocene formations of Turin cannot be relied upon.

The Nautilus appears to have been known to Aristotle, of whose shell-bearing polypi, the second is considered to be the Nautilus Pompilius; the first species, the true Nautilus of the ancients, and to which Gualtieri gave the name *Cymbium*, is the *Argonauta* of Linnæus. Although the shell of the recent Nautilus has long been commonly known, little information existed as to the animal, beyond that given by Aristotle, until a comparatively recent period. At the beginning of the last century the Dutch naturalist Rumph drew the attention of zoologists to the animal of the Nautilus; a description of which, illustrated by figures, he gave in his work 'D Amboinische Rariteitkamer.' From Rumph's description, which, however imperfect, was more intelligible than his drawing, De Montfort gave an imaginary representation of the animal, wide of the truth, but which was adopted by Shaw. After the time of Rumphius not any additional information was procured until the arrival in England, in 1831, of a specimen of the *Nautilus Pompilius*, taken by Mr. Bennett in Marachini Bay on the south-west side of the island of Erramonga, one of the New Hebrides. It is true that in the preceding year MM. Quoy and Gaimard had published, in the 'Annales des Sciences Naturelles,' an account of a portion of some unknown molluscous animal, which they supposed to be the *Nautilus Pompilius*, found near the island of Celebes; but the remains were too imperfect for satisfactory description, and, in fact, they have generally been attributed to a Heteropodous Mollusc, either Carinaria or Pterotrachea. The specimen brought over by Mr. Bennett was placed in the hands of Professor Owen, who in 1832 published his Memoir before referred to with minute anatomical descriptions and illustrations. In 1839 M. Valenciennes published an account entitled 'Nouvelles Recherches sur le Nautile flambé,' taken from an individual transmitted to the Museum of Natural History at Paris. These two works afford ample information as to the animal, but it is unnecessary to enter into the details, a brief outline, sufficient for the present purpose, having already been given. Of the soft parts of the animals which inhabited the fossil shells, no trace has been found to assist the Palæontologist, who must, therefore rely wholly on the calcareous remains for specific distinctions. As regards the tertiary species, these distinctions appear to be tolerably well defined; and but little difficulty will be found in the determination of the species.

The shell is smooth, spiral, and symmetrical; suborbicular, or somewhat depressed, and more or less round on the ventral aspect; the margins of the aperture are smooth and simple; the whorls are contiguous, and convoluted in a vertical plane, the last being the largest and concealing the rest, by which character it is distinguished from *Planulites*, the whorls of which are exposed. In some species the umbilicus is open; but more generally it is closed, as in the adult specimens of the recent *N. Pompilius*, by a deposition of nacreous or calcareous matter. The lines of growth are distinct, and in some species strongly marked, giving a somewhat striated appearance to the shell; and they are reflected backwards, in which respect they differ from those of the *Ammonitidæ*,

which are bent forwards. The chambers are separated by transverse partitions, more or less undulated; and in one species, *N. Parkinsoni*, they are distinguished by lateral angular lobes, resembling those of *Aturia* (*Nautilus*) *zic-zac*, and the margins are invariably simple and entire. The discs of the septa are perforated at the centre, or at parts more or less distant from the margins, but never at the margin, by a calcareous siphuncle, variable in size and generally discontinuous, that is, extending more or less into the preceding chamber, but not into the preceding siphuncular aperture. The chambers themselves increase in size to the last, which is sufficiently large to contain the whole of the animal; but the ratio of increase is apparently uncertain, and is influenced probably by the growth of the animal, which would, of course, depend on the supply of food and other circumstances.

The fossil substances termed *Rhyncolites*, which occur so frequently in the older formations, and which are generally believed to be the mandibles of some of the Tetrabranchiate Cephalopods, with whose remains they are associated, have been found both in the Paris basin and in the tertiary formations in Belgium; but I believe that as yet they have not been found in the Eocene strata of England.

The specific characters in this genus are taken from the curvature of the septa, the general outward form of the shell, (which, in fact, determines the shape of the septum,) the position of the siphuncle and the condition of the umbilicus. With respect to the terms *dorsal* and *ventral*, it must be borne in mind that they are used in the following descriptions in a sense directly the reverse of that in which they have been generally applied. The Nautilus, in its normal position, rests upon, or creeps along the ground by means of, the free and expanded anterior portion of the mantle. In this position the back of the animal is against the penultimate whorl of the shell, and the ventral part is contained within the concavity of the dwelling-chamber. In the following descriptions, therefore, the term *dorsal* is used to designate the parts contiguous to the penultimate volution of the shell, and which have been generally, though incorrectly, described as ventral; and the term *ventral*, on the other hand, will be applied to those parts on which the belly of the animal rested, and which hitherto have usually been termed dorsal.

At present six species have been found in the tertiary strata of England, and they are confined to the older Eocene deposits. In the contemporaneous strata of the Paris basin two species occur, one of which is also found in Belgium; but not either of them has as yet been found in England; and four species have been described by Sismonda and Michelotti, as occurring in the Miocene formations in Piedmont. Two of these last species are referred by those authors to existing species; but the accuracy of the identification is questioned.

No. 7. NAUTILUS CENTRALIS. *Sowerby.* Tab. III, fig. 1*a*—*c*.

NAUTILUS CENTRALIS. *J. Sow.* 1812. Min. Con. vol. i, p. 11, tab. 1, left-hand figure.
— AUSTRALIS (by error for CENTRALIS). *Defrance.* 1825. Dict. des Sc. Nat. vol. xxxiv, p. 297.
— CENTRALIS. *Wetherell.* 1836. Philos. Mag. and Journal, vol. ix, p. 465.
— BUCKLANDI. (?) *Michelotti.* 1840. Ind. rag. di alcuni Testacei de Cefal. foss. &c. Ann. delle Scien. del Regno Lomb.-Veneto, p. 4.
— CENTRALIS. *Morris.* 1843. Cat. Brit. Foss. p. 182.
— — *Pictet.* 1845. Traité élément. de Paléont. vol. ii, p. 338.
— — *Sow.* 1849. Dixon's Geol. Hist. &c. pp. 110, 121, tab. 14, fig. 28.

N. testâ globosâ, in aspectu ventrali rotundatâ; aperturâ semilunari; umbilicatâ, umbilicis angustis, profundis; septis extûs concavis, simplicissimis, siphone centrali, minimo, continuo perforatis; lobis dorsalibus latis, haud reflexis.

The N. centralis, in the simplicity of the septa and the central position of the siphuncle, nearly resembles the recent Nautili. It is a very ventricose, almost a globose shell, much rounded on the ventral aspect; the aperture is bluntly lunate, nearly semicircular, and is rather more than twice as wide as it is long; the open umbilicus is narrow and deep; the septa are concave outwardly, and simple, scarcely presenting any undulation or second curvature whatever; the dorsal lobes are broad, each being nearly one third of the width of the aperture, and they are bluntly rounded on their superior margins; the siphuncle is very small, central, or nearly so, and continuous. The lines of growth present broad undulations, and are strongly marked and decussated.

Michelotti has described a Nautilus from the Miocene formations of the Colle de Torino, in Piedmont, to which he has given the name *Bucklandi*. He quotes *N. centralis* of Sowerby by the name *N. australis* (an error into which he has fallen by relying on Defrance's quotation), and he considers his shell to be identical with it, and, oddly enough, associates with it *N. imperialis*. The specific description given by this author agrees tolerably well with that of the present species; but I have not myself had any opportunity of comparing the Piedmontese with the English shell; and as Michelotti does not mention his having compared the two, and he appears to have trusted implicitly to Defrance, the accuracy of the identification must for the present be considered as doubtful.

Mr. Wetherell, in his paper above quoted, gives this species and *Naut. regalis* as characteristic of the middle division of the three which he thinks might be made of the true London Clay. It occurs at Regent's Park, Chalk Farm, Hyde Park, Richmond, Sheppy, and Bognor; it is also found, though very rarely, at Bracklesham Bay.

The species does not appear to have attained a great size, the largest specimen not exceeding 3·7 in. in diameter, by 3·3 in. across. The figs. 1 and 2, Tab. III, are taken from specimens in the collection of Mr. Wetherell; fig. 3, from one in that of Mr. Sowerby. The form of the septum is shown by fig. 2, Tab. VIII.

No. 8. NAUTILUS REGALIS. *Sowerby.* Tab. IV.

NAUTILUS REGALIS.	*J. Sow.* 1823. Min. Con. vol. iv, p. 77, pl. 355.
—	—	*Def.* 1825. Dict. des Sc. Nat. vol. xxxiv, p. 300.
—	—	*Weth.* 1836. Philos. Mag. and Journ. vol. ix, p. 465.
—	—	*Morris.* 1843. Cat. Brit. Foss. p. 183.
—	—	*Pictet.* 1845. Traité élément. de Paléont. vol. ii, p. 338.
—	—	*Sow.* 1849. Dixon's Geol. Hist. &c. p. 120.

N. Testâ lævigatâ, sub-ventricosâ, in aspectu ventrali compressâ, obscurè undulatâ; aperturâ obtusè-ellipticâ; umbilicis obtectis; septis simplicibus, concavis, utroque latere perparum undulatis, siphone sub-centrali perforatis; lobis dorsalibus brevibus, rotundatis, haud reflexis.

The present species is distinguishable from the preceding by the closed umbilicus, and by its general form, which is less ventricose than that of *N. centralis.* It is a smooth shell, flattened on the sides, and bluntly rounded, and obscurely undulated on the ventral aspect. The aperture presents a subquadrate appearance. The umbilicus is closed by a thickening of the lip, assuming the appearance of a solid axis to the shell. The septa are nearly simple, presenting on each side slight undulations, and the short, rounded dorsal lobes are deeply concave, and not reflected. In the young shell the septum is characterised by a conical depression placed on the dorsal margin close to the preceding whorl; as the shell enlarges this gradually decreases in size and depth, and ultimately disappears. It was of course moulded on a corresponding protuberance on the animal, probably an enlargement of the epithelial cincture. In some species the cavity is very deep. It was on this character that De Montfort, mistaking the depression for the mouth of a second siphuncle, founded his genus Bisiphites. The siphuncle is small and excentric. The lines of growth, like those of the preceding species, are decussated, and reflected backwards in broad undulations.

The Nautilus regalis attained a large size. The specimen figured, for the use of which I am indebted to Mr. Dixon, measures 9·5 in. in diameter, by 5 in. across. The species occurs at Islington, Regent's Park, Chalk Farm, Hyde Park, and at Bognor. It appears to have been one of the most common of the English Eocene Nautili. The septum is represented at Tab. VIII, fig. 5.

No. 9. NAUTILUS URBANUS. *Sowerby.* Tab. III, fig. 2 *a*—*b*.

NAUTILUS URBANUS.	*J. D. C. Sowerby.* 1843. Min. Con. vol. vii, p. 36, pl. 628.
—	—	*Morris.* 1843. Cat. Brit. Foss. p. 183.
—	—	*Pictet.* 1845. Traité élément. de Paléont. vol. ii, p. 338.

N. Testâ discoideâ, in aspectu ventrali rotundatâ, et obscurè undulatâ; umbilicatâ; aperturâ subquadratâ, elongatâ; septis oblongis, concavis, in utroque latere leniter undulatis et siphone excentrico perforatis; lobis dorsalibus perbrevibus, obliquè truncatis, haud reflexis.

A flat discoidal shell, rounded on the ventral aspect, and presenting obscure undulations similar to those which characterise *N. regalis*. The aperture has an elongated, subquadrate shape; the umbilicus is narrow; the septa concave, and slightly undulated; they present on each side, in a line with the preceding whorl, a slight depression, which appears to be the first indication of the lateral lobes so fully developed in the *N. Parkinsoni;* the siphuncle is excentric approaching the dorsal margin; the dorsal lobes are short, very slightly concave, obliquely truncated, and not recurved. The lines of growth are prominent, and decussated more strongly than those of the two preceding species, and their undulations are broad and shallow.

The Nautilus urbanus is distinguishable from *N. centralis* by its flatness, and the greater length of its aperture; and from *N. regalis* by its open umbilicus, the truncated extremities of the dorsal lobes of the septa, and its discoidal shape. It is a very rare shell. The figures 2*a*, 2*b*, Tab, III, are taken from the shells drawn in 'Mineral Conchology,' the only specimens with which I am acquainted. The larger one, belonging to Mr. Sowerby, was found in excavating St. Katharine's Docks, near the Tower of London; the smaller one forms part of Mr. Bowerbank's collection, and was obtained from Sheppy.

The size of the larger individual figured is 7·4 in. in diameter, by 3·4 in. Fig. 4, Tab. VIII, represents the septum.

No. 10. NAUTILUS IMPERIALIS. *Sowerby*. Tab. V.

NAUTILUS IMPERIALIS.	*J. Sow.* 1812. Min. Con. vol. i, p. 9, tab. 1, upper and right-hand figures.
—	—	*Defrance*. 1825. Dict. des Sci. Nat., tome xxxiv, p. 297.
—	—	*Wether*. 1836. Philos. Mag. and Journ. vol. ix, p. 465.
—	BUCKLANDI.	*Michelotti*. 1840. Indice ragionato, &c. p. 4.
—	IMPERIALIS.	*Morris*. 1843. Cat. Brit. Foss. p. 182.
—	—	*Pictet*. 1845. Traité élément. de Paléont. vol. ii, p. 338.
—	—	*Sowerby*. 1849. Dixon's Geol. Hist. &c. pp. 110, 120.

N. Testâ sphæroidale; umbilicatâ, umbilicis angustis, profundis; aperturâ subellipticâ, semilunari; septis undatis, siphone mediocri dorso-excentrali perforatis; lobis dorsalibus latis et perparum reflexis.

This species is easily distinguished from the *N. centralis* by the excentric position of the siphuncle, as well as by the broad and reflected extremities of the dorsal lobes, which form, as it were, an axis to the shell. Its orbicular form, the lunate shape of the septa, and the recurved dorsal lobes, distinguish it as clearly from *N. regalis* and *N. urbanus*.

The *Nautilus imperialis* is a somewhat globose shell, rather narrow on the ventral aspect, whence the aperture assumes a sub-elliptical form; the umbilicus is small and deep. It is well displayed in the large figure, Tab. V, taken from a specimen in Mr. Bowerbank's collection, but generally, it is found open only in young shells; in the larger specimens it is usually filled with pyrites or indurated clay. The septa are deeply concave, and present a gentle undulation on each side; the dorsal lobes are very broad, inflected towards the axis, and obliquely truncated on the inferior margins. The siphuncle is moderately large, and excentric, being placed on the dorsal side of the centre of the disc. It appears to vary in its position, gradually becoming more distant from the dorsal margin as the shell enlarges. The lines of growth are reflected backwards in a deep narrow wave, and in the specimens I have seen are not decussated as in the three preceding species.

In the shell described by Michelotti under the name *N. Bucklandi*, and with which he has associated the present species, the siphuncle is central; and that character is, in fact, the reason assigned by him for considering his shell to be identical with *N. centralis* as well as with *N. imperialis*. Whether the alleged identification of *N. Bucklandi* with *N. centralis* be correct or not, it is obvious that the Piedmontese shell cannot be referred to the present species. Defrance states that the *N. imperialis* did not appear to differ from *N. centralis*, and Michelotti has, in fact, relied implicitly on that author; he has even copied the mistake made in quoting *N. centralis* as *N. australis*.

The *N. imperialis* attained a very large size; a specimen from Sheppy in the Museum of the Geological Society measures 12 inches by 8·75 in. across. It appears to have been widely spread, being found at Highgate, Hornsey, Brentford, Sheppy, Cuffell near Basingstoke, Clewett's Green, Newnham, Bognor, and Bracklesham. The form of the septum is shown in Tab. VIII, fig. 1.

No. 11. NAUTILUS SOWERBYI. *Wetherell.* Tab. VI.

NAUTILUS SOWERBYI. - *Weth.* 1836. Phil. Mag. and Journ. vol. ix, p. 466.
— — *Morris.* 1843. Cat. Brit. Foss. p. 183.
— — *Sow.* 1843. Min. Con. vol. vii, p. 35, pl. 627, fig. 1-3.
— — *Sowerby.* 1849. Dixon's Geol. Hist. &c. p. 121, tab. 14, fig. 28.

N. Testâ lævigatâ, lenticulari, ventrali aspectu angustè rotundatâ; umbilicatâ, aperturâ sub-triangulari; septis profundè concavis; siphone continuo, prope margines dorsales posito, perforatis; utroque latere latè undulosis et sublobatis; lobis dorsalibus elongatis, valdè reflexis, obliquè truncatis.

The *N. Sowerbyi* is an exceedingly well-marked species. It is a smooth, discoidal, convex or rather lenticular shell, somewhat resembling in shape the Dax form of

Aturia (*Nautilus*) *zic-zac*, but it is narrower towards the margin, which circumstance gives a triangular form to the aperture. The septa (Tab. VIII, fig. 3) are very concave, and present on each side a broad undulation, with a deep sinus-like depression caused by a lateral lobe, more developed in this species than in *N. urbanus*, although not attaining the size and importance of that which distinguishes *N. Parkinsoni*.

The dorsal lobes are much recurved and obliquely truncated; the siphuncle is moderately large, placed very near to the dorsal margin, and continuous. The striæ of growth towards the middle are suddenly bent backwards in deep undulations.

This species, which attained a size of 10 inches in diameter by 4·2 in. across, was first obtained by Mr. Wetherell from the tunnel made at Chalk Farm for the Birmingham Railroad. It has also been found in the cuttings now in progress between Whetstone and Barnet for the Direct Northern Railroad, and it occurs at Sheppy and at Bognor, where it is very common.

No. 12. Nautilus Parkinsoni. *F. E. Edwards.* Tab. VII.

Nautilite. *Parkinson.* 1811. Organic Remains, p. 105, pl. 7, fig. 15.

N. testâ discoideâ, aperturâ elongato-ellipticâ, parietibus convexis; umbilicis (?); septis extûs concavis, in utroque latere angulariter lobatis, siphone, prope margines dorsales posito perforatis; lobis lateralibus brevibus, subtriangularibus, mucronatis; lobis dorsalibus latis, perparum concavis, ad extremitates attenuatis, reflexis.

Parkinson, in his work above cited, described the remains of a Nautilus, purchased by him at the sale of Dr. Menish's collection. These remains, which consist of the casts of three chambers, afterwards came into the possession of Mr. Sowerby, who has placed them at my service. Parkinson was ignorant of the locality whence they came; but from their mineralogical character, the matrix being, in fact, the substance known as cement-stone, it was supposed that they were found at Harwich. Lately the Rev. Thomas Image, of Whipstead, near Bury St. Edmunds, has forwarded to me for examination similar remains, unquestionably obtained at Harwich, and consisting of the casts of two chambers, rather smaller than those in Parkinson's specimen, and in a matrix precisely similar. The question, therefore, as to the locality of Parkinson's specimen is set at rest.

These remains are particularly interesting, from the circumstance that in them the angularly-lobed septum which characterises *Aturia* (*Nautilus*) *zic-zac*, and in that shell is accompanied by a strictly dorsal siphuncle, is associated with one which, although very excentric, is still so truly discal, as to prevent the shell being removed from the present genus. The form of the septum is a good specific character, but it cannot be relied upon as a generic distinction. The *Nautilus Parkinsoni*, therefore, although in general appearance it closely resembles *Aturia*, must, in fact, from the position of the siphuncle

be considered as an aberrant *Nautilus*, connecting that genus with *Aturia*, and leading through the *Clymenidæ* into *Goniatites* and *Ammonites*.

The *N. Parkinsoni* is a discoidal shell, with regular convex sides, and an elongated elliptical aperture. The specimens do not exhibit the condition of the umbilicus. The septa are outwardly moderately concave, with angular lobes on each side; the dorsal lobes are very broad, somewhat concave, rounded at the extremities, and reflected, although not much, towards the axis; the lateral lobes are short, wide at the upper extremities, and they taper rather suddenly; their inferior margins are nearly straight, but the superior margins present a deep sinus. The siphuncle is moderately large, and is placed on the dorsal part of the septal disc, half way between the centre and the margin. So far as the general character can be ascertained, the siphuncle does not appear to differ from that of *Nautilus*, and certainly does not present any analogy with the wide trumpet-mouthed funnel which distinguishes *Aturia*.

This species appears to have attained a greater size than any other of the tertiary Nautili; the largest chamber in Parkinson's specimen measures seven inches in breadth, and nine inches in length; and this chamber was not the last, and consequently not the largest.

Family—Clymenidæ.

Aganidæ. ***Pictet, Deshayes, D'Orbigny.***

Adopting the opinion of Von Buch, that the position of the siphuncle is the principal, if not the only, character by which the Tetrabranchiate Cephalopods can be divided into families, it becomes impossible to include those genera in which the siphuncle is placed on the *dorsal* margin, either among the Nautilidæ, in which it is *central* or *excentric*, or among the Ammonitidæ, in which it is placed on the *ventral* margin. The only genera at present known to possess a strictly dorsal siphuncle, are *Clymenia*, Munst. (*Endosiphonites*, Ansted), and *Aturia*, a genus proposed by Bronn for the *Nautilus Aturi*, Basterot (*N. zic-zac*, Sow.) In fact, these genera have already been considered by MM. d'Orbigny, Deshayes, and others, to form a subdivision of the Nautilidæ, to which those authors have applied the name Aganidæ, founded on a genus proposed by De Montfort for a shell from the mountain limestone. This shell, however, possessed a ventral siphuncle, and belonged to the genus Goniatites.* The name *Aganidæ*, therefore, cannot with propriety be retained as a family name for genera characterised by a *dorsal* siphuncle; and I have adopted, in lieu of it, the name *Clymenidæ*, founded on Munster's genus.

* The shell figured and described by De Montfort as *Aganides* is, I believe, the *Goniatites sphæricus* of Sowerby.

The septa in the *Clymenidæ* are distinguished by lateral rounded or angular lobes; but the angular form is not peculiar to the family; since, as we have already seen, it is found in *Nautilus Parkinsoni*, a species which, possessing an excentric siphuncle, must be considered as merely an aberrant form of Nautilus; and the separation of the *Clymenidæ* will depend entirely on the siphuncle being placed on the dorsal margin.

The two genera which belong to this family are distinguished chiefly by the mode of involution of the shell; the whorls in *Clymenia* being exposed, while in *Aturia* the last whorl conceals the rest; they therefore bear to each other the same relation which *Planulites* bears to the true *Nautilus*.

Genus 5th. Aturia.* *Bronn*, 1837.

Gen. desc. *A. testâ discoideâ vel subventricosâ, spirali, multiloculari, parietibus simplicibus; anfractibus contiguis, ultimo alios obtegente; umbilicis clausis; septis transversis, numerosis, extùs concavis, utroque latere angulariter lobatis et parte dorsali, magnâ siphone infundibuliformi, marginibus positâ, retro prolongatis; marginibus simplicibus.*

Shell discoidal or subventricose, spiral, multilocular, sides simple; whorls contiguous, the last concealing the others; the umbilicus closed; septa transverse, numerous, concave outwardly, with an angular lobe on each side, and having the dorsal part prolonged backwards, forming a large, marginal, funnel-shaped siphon; margins of the septa entire.

The angularly-lobed septum which distinguishes *Nautilus Parkinsoni* also forms a prominent character in the well-known Highgate fossil, *Naut. zic-zac*, figured and described by Mr. Sowerby in the first volume of the 'Mineral Conchology.' Bronn, in his description of the Dax shell *Nautilus Aturi* (Bast.), which he considered to be distinct from *N. zic zac*, suggested the propriety of forming a sub-genus, to be called *Aturia*, for the reception of those tertiary Nautili in which, according to the sub-generic description given by him, "the siphon is sub-ventral (i. e. sub-dorsal), and the septa have a deep, narrow, lancet-shaped flap on each side." The siphuncle, however, in the Dax shell, on which the genus is founded, is, in fact, strictly *marginal;* it is, as Bronn himself describes it, a prolongation backwards of the dorsal part of the septum, in the shape of a wide-mouthed funnel, extending quite across the preceding chamber, and deeply into the mouth of the preceding funnel. As this funnel-shaped siphon decreases in diameter, the dorsal paries gradually recedes from the margin, and the intervening space is filled up with a calcareous deposit. The siphuncle, therefore, will in some parts of its extent appear to be sub-marginal only: whereas the mouth of the

* Etym. Aturrus *vel* Aturus—the River Adour.

siphuncle, by which only the position can be determined, is perfectly marginal. The *Nautilus Aturi*, which I consider to be identical with *Nautilus zic-zac*, is the type of Bronn's genus, and I therefore retain the name proposed by that author, although I do not assent to the accuracy of his generic description.

The genus *Clymenia*, proposed by Count Munster for certain Nautiliform remains occurring in the transition limestones of Fichtelgebirge, presents nearly the same characters as those assigned by me to *Aturia;* except that in *Clymenia* the whorls are exposed, and the siphuncle is described as narrow; whereas in *Aturia* the last whorl conceals the others, and the siphuncle, at least in *A. zic-zac*, the typical species, is of great size.

The genus appears to have been confined to the tertiary epoch, and it is widely diffused. It occurs in the Eocene formations of England, France, Belgium, and Germany; in the Miocene deposits in the basins of the Gironde, in Italy, and in Malta. It is also found in the Eocene formation in Clarke county, Alabama, (U. S.), and Conrad* mentions a cast from the contemporaneous formation near Long Branch, New Jersey, resembling Nautilus (Aturia) zic-zac, but more compressed, and which he has referred to De Montfort's genus *Pelagus*, and has named *P. Vanuxemi*. De Montfort's *Pelagus*, however, is described as having "cloisons lobées, *persillées, dentelées*, &c." The position of the siphuncle is not mentioned in De Montfort's text; but in the figure he has given it is placed on the ventral margin. The shell, therefore, on which the genus Pelagus is founded is an Ammonite, and the species constituting the present group cannot be associated with it.

No. 13. ATURIA ZIC-ZAC. *Bronn.* Tab. IX, fig. 1*a*—*h*.

Var. *a*. NAUTILUS ZIC-ZAC. *Sow.* 1812. Min. Con. vol. i, p. 9, pl. 1, fig. 3.
AMMONITES WAPPERI. *Van Mons.* 1833. L'Institut. 1833, p. 272.
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— ATURI. *Bronn.* 1837. Leth. Geog. vol. ii, p. 1123, pl. 42, fig. 17*a*—*c*.
— ZIC-ZAC. *Desh.* 1837. Desc. des Coq. foss. des Env. de Paris, vol. ii, p. 765, pl. 100, figs. 2, 3.
CLYMENIA ZIC-ZAC. *Michelotti.* 1840. Annal. Scient. reg. Lomb. Venet. p. 6.

* Conrad's "Observations on the Eocene formation, and description of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Mississippi," published in the Journal of the Academy of Natural Science of Philadelphia.

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— — — 1843. Desc. des Coq. foss. &c. des Terr. tert. de la Belgique, p. 644, pl. 46, fig. 4.
— — *Morris.* 1843. Cat. Brit. Foss. p. 183.
Aganides Deshayesii. *Sismonda.* 1847. Method. Anim. invert. Pedemontii Foss. p. 57.
— zig-zag. *Pictet.* 1845. Traité élément. de Paléont. Vol. ii, p. 341.
Nautilus (Clymenia ?) zic-zac. *Sow.* 1849. Dixon's Geol. Hist. &c. p. 109, pl. 8, fig. 19.
Var. β. Nautile de Dax. *De Montf.* 1802. Buffon de Sonnini Moll. vol. iv, pp. 240, 252, pl. 46, fig. 1.
Nautilus Pompilius. *Lam.* Ann. du Mus. vol. v, p. 181.
— — — 1822. An. sans Vert. vol. xvi, p. 634.
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— Aturi. *Bast.* 1825. Desc. des Coq. foss. des Env. de Bordeaux, p. 17.
Orbulites zic-zac. *De Blainv.* 1825. Man. de Malac. p. 387.
Nautilus (Aganides) Aturi. *D'Orb.* 1825. Tab. méthod. de la Classe des Céph. p. 71.
— Sypho. *Buckl.* 1836. Bridgw. Treat. vol. i, p. 357, pl. 46, figs. 1-4.
— — *Grateloup.* 1838. Cat. des An. vert. et invert foss. du Basin de la Gironde, p. 28.
Aganides Aturi. *Pictet.* 1845. Traité élément. de Paléont. Vol. ii, p. 341.

A. Testâ ventricosâ, lævigatâ; umbilicis clausis; septis concavis; lobis lateralibus angustis, acutis; dorsalibus valdè recurvis; siphone magno, continuo, buccinæformi.

Var. β. *Testâ compressâ, sub-discoideâ; septis profundè concavis, lobis dorsalibus angustioribus.*

Shell ventricose, smooth; umbilicus closed; septa concave; lateral lobes narrow, pointed; dorsal lobes much curved; siphuncle large, continuous, trumpet-shaped.

There are scarcely any tertiary remains which have excited so much attention as the present; not merely because the species is widely diffused, but because it presents an intermediate form between the Nautili and the Ammonites; and few fossils have been referred to more genera, or have been distinguished by a greater number of specific names.

The *Aturia zic-zac* was first described by Mr. Sowerby, sen., as Nautilus zic-zac, from a specimen which was found on forming the tunnel of the Highgate Archway. Several years afterwards M. Defrance described a specimen from the Paris basin, and pointed out the differences which, in his opinion, rendered it difficult to refer the species to the genus *Nautilus*. M. Defrance considered the fossil described by him as distinct from the *N. zic-zac*, and gave to it the specific name *Deshayesii*. Subsequently Basterot described the well-known Dax fossil, which he named *Naut. Aturi*, and with which he considered the *Naut. zic-zac* to be identical. M. d'Orbigny and Sig. Sismonda, not regarding the dorsal position of the siphuncle, but relying on the angular lobes which characterise the septa, have referred the shell in question to De Montfort's *Aganides*, a genus which, as has been before stated, was founded on a *Goniatite* from the mountain limestone. Michellotti, on the other hand, has considered

the present remains as forming part of Munster's *Clymenia*, a genus distinguished by its having the whorls exposed.

The Aturia zic-zac is a smooth, involute shell, more or less ventricose or depressed; the septa are outwardly deeply concave; and, owing to the regular curve in which the dorsal lobes are reflected towards the axis of the shell, they present, when viewed sideways, some resemblance to the letter S; the lateral lobes are more or less narrow, and taper rather suddenly towards the inferior extremity, which extends nearly to the preceding septum; but they are without the sinus which characterises the lateral lobes of *Naut. Parkinsoni*. The English shells are generally either casts in, or filled with pyrites, and it is difficult to ascertain the character of the siphuncle from them; but in the Dax shells, in which the calcareous siphon is frequently well displayed, it presents a structure widely different from that of the Nautilus. The dorso-marginal part of the septum, as I have before observed, is prolonged backwards in the form of a wide trumpet-mouthed funnel, which extends not only into the mouth of the funnel formed by the preceding septum, but along the preceding siphuncle almost to the floor of the third preceding chamber (see Tab. IX, fig. 2*a*). The calcareous siphuncle, therefore, is, in fact, a continuous tube of considerable thickness, composed of portions of two distinct tubes; and within this is contained a soft, friable, calcareous sheath, which commences near the extremity of the funnel, where it touches the preceding funnel, and extends to the end of the preceding funnel, to the interior surface of which it forms a sheath. Although, owing to the thickness of the walls and the presence of the calcareous sheath, the actual tube within which the membranous siphuncle was contained is not so capacious as might be expected from its external appearance, it is yet considerably larger than that of any of the tertiary Nautili; and indeed it is of such size and importance as fully to justify the name *Sypho*, which Grateloup has given to the Dax shell. The siphuncle in the English specimens, so far as its character can be ascertained, appears to correspond exactly with that of the Dax shells.

Great diversity of opinion has existed, and, in fact, still exists, as to the identity of the Dax shell with the *Naut. zic-zac* of Sowerby. The differences which have been relied on for the separation of the two appear to me to result from the more compressed form of the Dax shells; the specimen figured by Mr. Sowerby, although described as "flattish," being ventricose, and the outline of one of the septa drawn below the shell conveying the idea of greater fulness than in fact characterises the fossil. M. Deshayes, who compared the Dax shells with specimens as well from the Paris basin as from Belgian and English localities, expressed an opinion that the differences were sufficient to form, if not two species, at least two well-marked varieties. I have not myself had an opportunity of examining any French or Belgian specimens; but, through the kindness of Mr. Sowerby, Mr. Bowerbank, and Mr. Wetherell, who have afforded me the use of their specimens, I have before me a series of shells from Sheppy and the

neighbourhood of London, including the identical specimen figured by Mr. Sowerby. Confining myself to external characters only, two distinct forms occur in this series, the differences in which, although they may require a separation into varieties, are not sufficient, in my opinion, for specific distinctions.

In the first variety, which is the true Naut. zic-zac, figured in ' Mineral Conchology,' and which I have therefore taken for the typical form, the shell is ventricose, the greatest width being little less than half the diameter; it is moderately round on the ventral aspect, and the aperture is a somewhat elongated ellipsis. In the other variety (β) the shell is more compressed, almost discoidal; and consequently it is narrower on the ventral aspect; the dorsal lobes are not so broad, and the aperture is of a more elongated oval form.

The French, Belgian, and German shells correspond apparently with the first, the typical form, and the Dax shells agree closely with the second variety. Michellotti has used for the Piedmontese specimens the specific description given by M. Deshayes; but he adds, that " they present some trifling differences from the Paris specimens, as do the latter from the London and Bordeaux shells." As, however, the Piedmontese shells are described as " ventricose," they must for the present be referred to the typical form, although we should naturally expect to find the Dax type continued in the Miocene formations of the Colle de Torino.

The Aturia zic-zac also occurs in the Miocene deposits in Malta, and the specimens which I have seen from that locality present the depressed form of the Daxshells, with which they agree in other respects.

Mr. Sowerby possesses a series of casts from the Eocene formation in Clarke County, Alabama, of a species which approaches very near to the typical *Aturia zic-zac;* the chief distinction appears to be in the form of the lateral lobes, which in the American shell extend quite to the margin of the preceding septa, and have their extremities inflected towards the axis, and present the deep sinus which characterises the lateral lobes of *Naut. Parkinsoni.* The siphuncle is very large, and corresponds with that of *A. zic-zac.* Conrad describes his *Pelagus Vanuxemi* as more compressed than the latter shell, and he adds that " the angles of the septa appear to be in contact near the periphery." This appearance, which is attributable to the length of the lateral lobes, and is represented in the figure given by Conrad by a continuous line running parallel with the periphery of the shell, is also found in the Alabama specimens, of which Conrad's shell is possibly only a compressed variety.

The typical form, which is represented at Tab. IX, fig. 1*a*, 1*b*, drawn from the original specimen figured in ' Mineral Conchology,' for the use of which I am indebted to Mr. Sowerby, is found at Highgate, Sheppy, and Bracklesham Bay. The variety β, which corresponds with the Dax shells, was obtained from the railroad cutting at Chalk Farm, and from the well sunk for the use of the Orphan School, at Haverstock Hill,

near Hampstead. The specimen figured (Tab. IX, fig. 1*g*, 1*h*,) is from the former locality; it is the one drawn by Mr. Charlesworth in the 'Magazine of Natural History,' vol. i, (new series,) p. 533, and forms part of Mr. Wetherell's valuable collection of fossils from Highgate and the neighbourhood.

The English shells are apparently young; they are much smaller than the Dax specimens, the largest I have seen cannot have exceeded 1·6 in. in diameter.

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TAB. I.

Fig.

1. Belosepia Sepioidea, *p.* 29.
   - 1*a*—*c*. Var. B. longirostris.
     - *a*. Dorsal aspect.
     - *b*. Side view.
     - *c*. Ventral aspect.
   - 1*d*—*f*. Var. B. longispina.
     - *d*. Dorsal aspect.
     - *e*, *e'*. Side views.
     - *f*. Ventral aspect.
   - 1*g*—*i*. Var. B. Blainvillii.
     - *g*. Side view.
     - *h*. Do. of a cast of the Belosepion (B. Sepioidea).
     - *i*. Ventral aspect.
2. Belosepia brevispina, *p.* 32.
   - *a*. Dorsal aspect.
   - *b*. Side view.
   - *c*. Ventral aspect.
3. Belosepia Cuvieri, *p.* 31.
   - *a*, *d*. Ventral aspect.
   - *b*. Dorsal aspect.
   - *c*. Side view.
4. Dorsal aspect of the Belosepion (B. Sepioidea).
5. Longitudinal section of ditto.
6. Enlarged view of the terminal cavity and rostrum in the same section.
7. Enlarged view of an obliquely transverse section of the terminal cavity.
8. Dorsal aspect of the sepion (Sepia officinalis).
9. Longitudinal section of ditto.
10. Enlarged view of section of the rostrum of ditto.

TAB. II.

1*a*—*g*. Beloptera Belemnitoidea, *p*. 36.

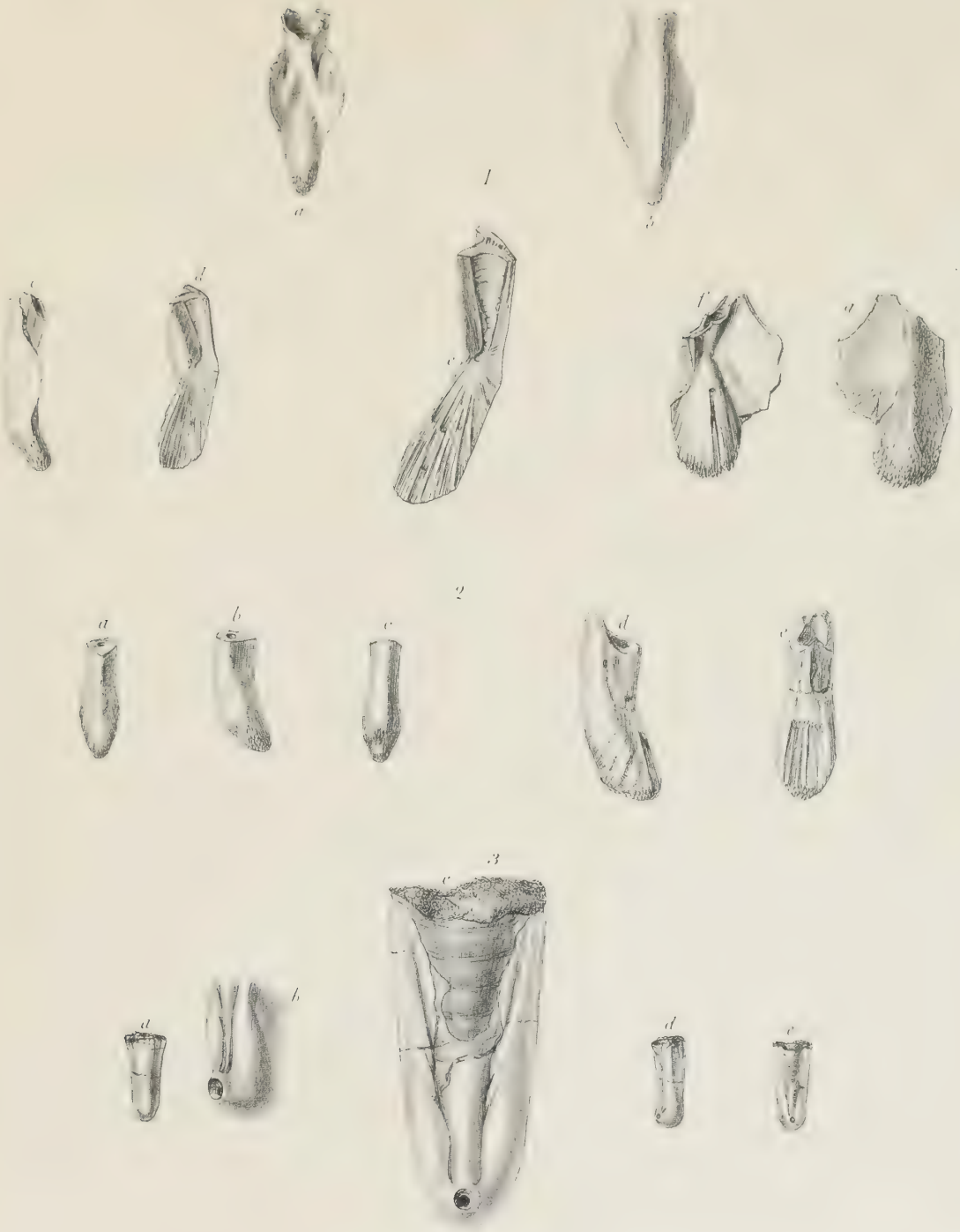
a. Ventral aspect.
b. Dorsal do.
c. Side view.
d. Longitudinal section.
e. Magnified view of do.
f. Ventral aspect of variety.
g. Dorsal aspect of do.

2*a*—*e*. Beloptera Levesquei, *p*. 37.

a. Ventral aspect
b. Side view
c. Dorsal aspect
} of a young specimen.
d. Side view of an adult specimen.
e. Ventral aspect of ditto.

3*a*—*e*. Belemnosis plicata, *p*. 40.

a. Dorsal aspect, nat. size.
b. Side view (enlarged) of the umbonal pore.
c. Ventral aspect enlarged.
d. Side view, nat. size.
e. Ventral aspect, ditto.


a
1
3
c
d
e
f
g
2
a
b
c
d
e
3
d
b
c
d
e

TAB. III.

Fig.

1*a*—*c*. Nautilus centralis, *p*. 45.

a. Back view.

b. Side view.

c. Do., young shell.

2*a*—*b*. Nautilus urbanus, *p*. 46.

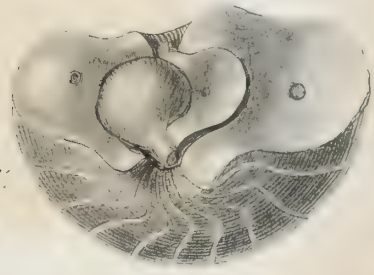
a. Side view, young shell.

b. Do., adult do.

J De C Sowerby fecit.

Nautilus regalis p 16.

J. De C. Sowerby fecit

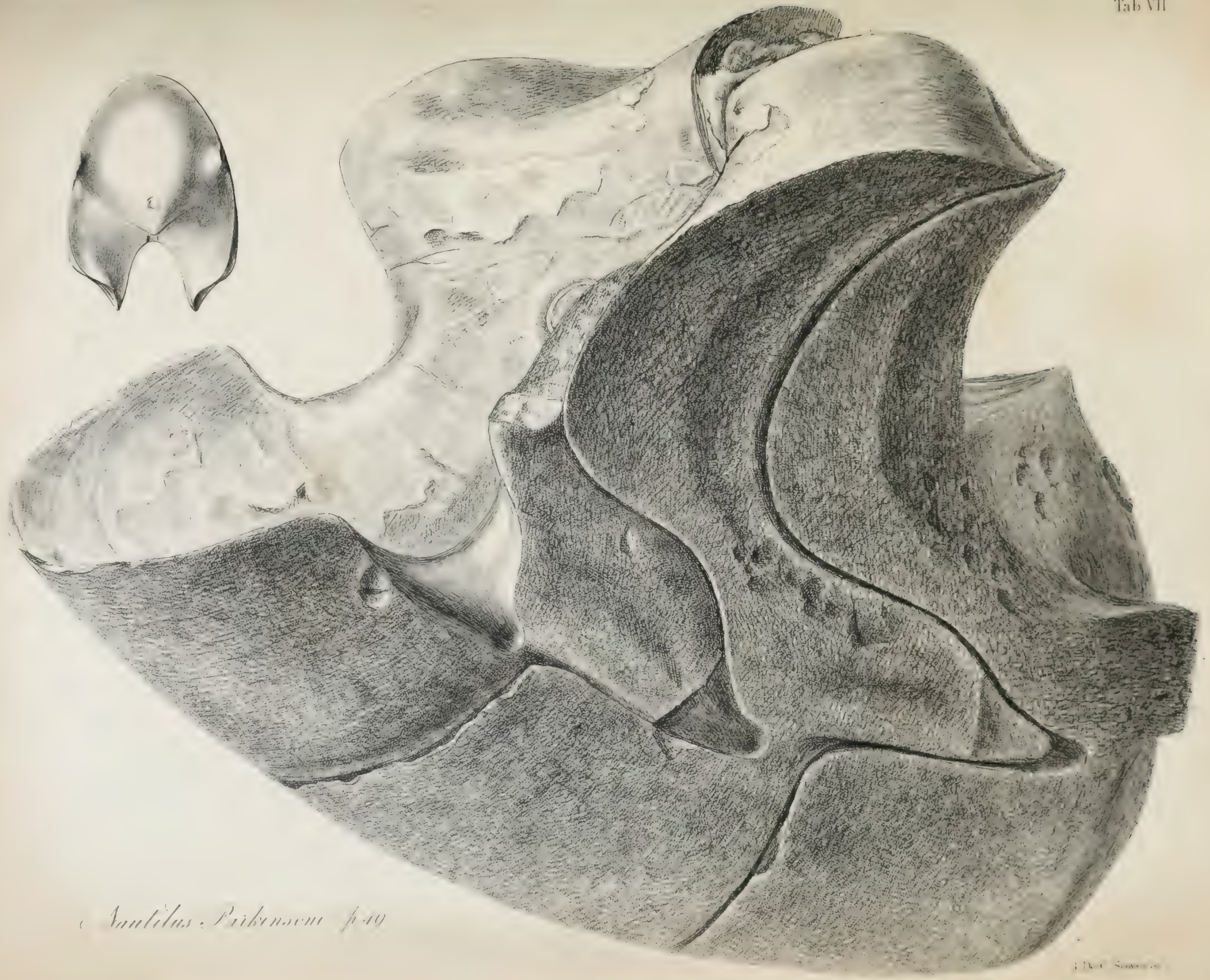


Nautilus imperialis p. 45.

J. De C. Sowerby fecit

Nautilus Sowerbyi p. 18

J. De C. Sowerby 1838



Nautilus Parkinsoni p. 40

TAB. VIII.

Fig.

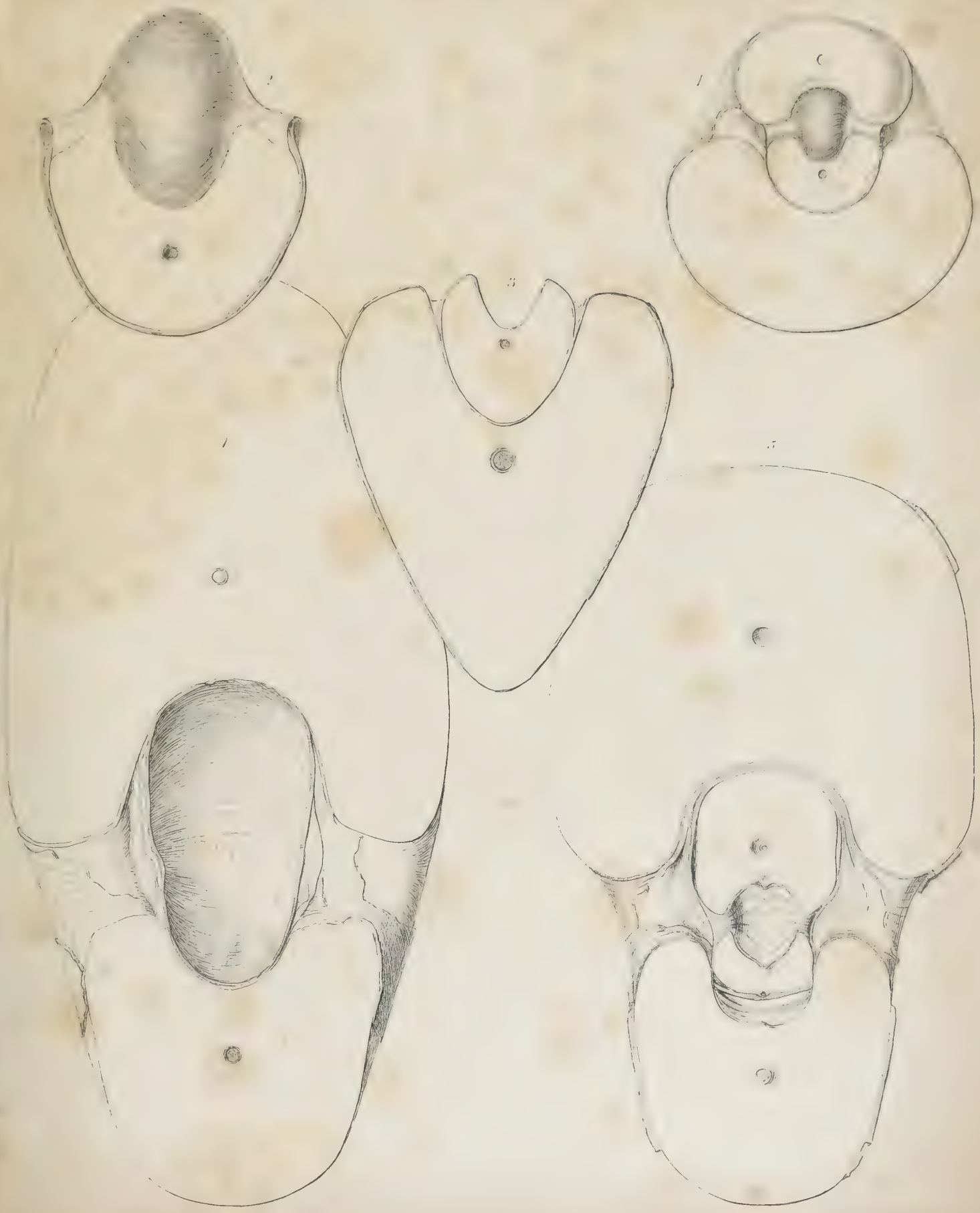
1. Transverse section showing the form of the septum in Nautilus imperialis, *p.* 47.

2. Do. do. N. centralis, *p.* 45.

3. Do. do. N. Sowerbyi, *p.* 48.

4. Do. do. N. urbanus, *p.* 46.

5 Do. do. N. regalis, *p.* 46.



J. De C. Sowerby fecit.

TAB. IX.

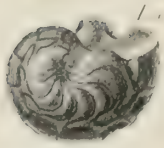
Fig.

1*a*—*h*. Aturia zic-zac (English specimens), *p*. 52.

a. Side view of the typical form, from Highgate.
b. Front view do. do.
c. Side view do. from Sheppy.
d. Front view do. do.
e. Side view do. from Bracklesham Bay.
f. Front view do. do.
g. Side view of the compressed variety (β), from Chalk Farm.
h. Front view do. do.

2 and 3. Aturia zic-zac (Dax specimens).

2. Oblique view, showing the construction of the siphuncle.
3. Front view, showing the form of the septum.



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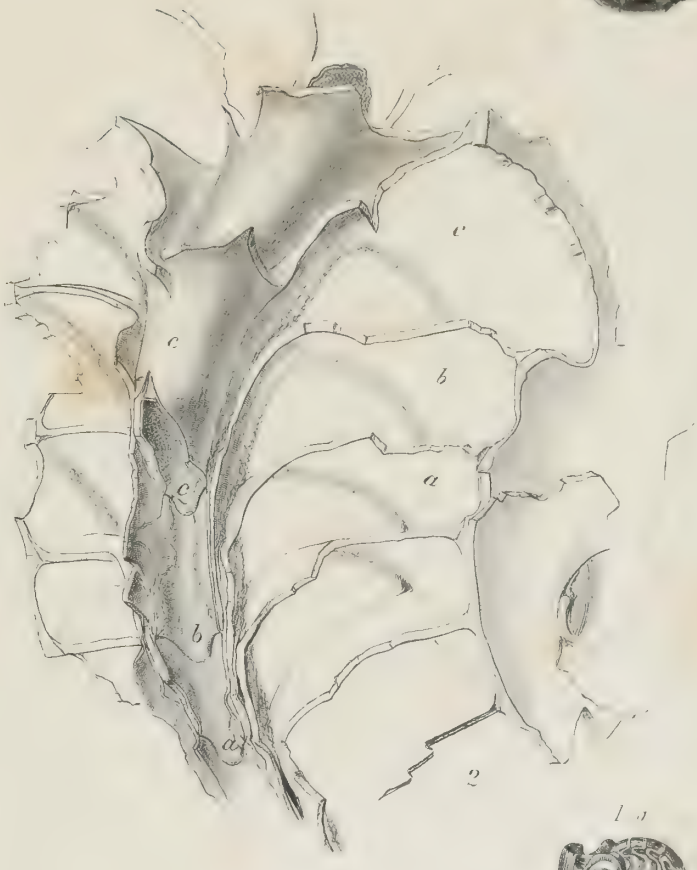

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